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Objectives as Determining Factors for Making a Course of Study in Junior High School Science

By Zay Barber, University of California.

(Continued from the November number.)

The exact content of the courses now being offered in various schools can be shown by an examination of several courses. The brief summaries given may be suggestive for the course of study makers.

ST. LOUIS, MISSOURI.

The Ben Blewett Junior High School gives this aim for its course:

The aim of this department is to build a sound foundation course for the seventh grade which shall serve to give the pupils glimpses of the interesting fields that science explores. Interest in the world about them, rather than amount of information, being the vital consideration, pupils are brought into contact with many different phases of elementary science. Conspicuous here also is the primary feature in all seventh grade work in Blewett Junior High, namely, the exploring of pupils' interests, aptitudes and abilities. General science in this grade aims to open up to them the larger scientific fields that lie beyond, to the end that wise educational guidance and pre-vocational choices may be made in higher grades. Topics discussed are as follows:

September.

(1) Landscape appreciation.
(2) Tree study: identifying the common trees; mapping school grounds.
(3) Bird study: permanent residents near school; migrating birds.
(4) General observation visit to the zoo.
(5) The best food for children (milk).
(6) Insect study: grasshopper and sphinx.

November.

(1) Landscape appreciation: November landscape.
(2) Tree study: winter aspect of common trees.

(3) Bird study: protective coloration, winter care of birds.
(4) Visit to the zoo: planned carefully for the study of one animal.
(5) Bulbs: why planted so early; why they bloom so early.
(6) Animal study: goldfish and squirrel.

February.

(1) Landscape appreciation: winter landscape.
(2) Tree study: complete survey of district, structure, enemies.
(3) Bird study: watching return of early spring birds.
(4) Visit to the bird cage of the zoo: planned lesson for observation.
(5) Bag worm.
(6) House fly: studied with a microscope.
(7) Tree products: lumber and lumber industry.

April.

(1) Landscape appreciation: April landscape; identification of common plants.
(2) Tree study: bird homes, temporary residents.
(3) Bird study: bird homes, temporary residents.
(4) School and home gardens: soil testing, seeding, germination.
(5) Animal study: earthworms, moths, butterflies, bumblebees.
(6) Food: when to eat fats, sweets, meats.

CITY OF NEW YORK.

The underlying aims are stated in the introduction to be: (1) To arouse and satisfy the normal pupil's curiosity in the common phenomena and familiar appliances of his environment, and by so doing to furnish him with an intelligent appreciation and comprehension of those phenomena and appliances; (2) to encourage the spirit of enquiry and to cultivate the attitude of independent judgment, of open-mindedness, and of reliance upon facts. Pupils are familiar with many applications of the principles of science as found in the houses in which they live, in their toys and games, in the street traffic, in the transportation systems on land and on water, and in the industries with which they come in contact. Much of this knowledge is, however, crude and incomplete. It is the teacher's problem to assist pupils to transform these crude experiences into organized knowledge.

As outlined for the seventh grade the course includes:

Water: In our city; utilization of water power; natural phenomena; buoyant properties.

Air: In our city; some material properties; air in motion; buoyant properties; utilization of changing air pressure and of compressed air.

Sound: Playing on musical instruments; some properties of sound; transmission, reflection, and direction of sound.

Heat: Combustion; heating; expansive effect of heat; measurement of temperature; vaporization and condensation; freezing of water and melting of ice.

The topics given for the eighth grade are: light, magnetism, electricity, gravity, inertia, centrifugal force, the water-wheel, the windmill, the steam-engine, the gasoline-engine, simple machines.

In the ninth grade the topics are an amplification of the seventh and eighth grade work, with special emphasis on the relation of plants, animals and man, and on the relation of the earth to the sun, moon and stars.

ROCHESTER, NEW YORK.

Rochester offers general science in the eighth and ninth grades. The general aim of the science work is:

(1) To develop the student's power of observation, so that he may be aware of his surroundings in a way that will enrich his experience.

(2) To give the students an understanding of the common phenomena of their immediate environment.

(3) To give an opportunity for practice in applying what has been learned to the solution of new problems.

(4) To correct misinterpretations of natural phenomena.

(5) To give students some idea of scientific methods of procedure in dealing with problems of a scientific nature.

The topics for study are arranged in groups and the information and training obtained by the study of any group is made to play a definite part in the study of succeeding groups. The arrangement of groups is somewhat determined by seasonal changes. The arrangement of topics within a group is either psychological or logical, as the case demands. Throughout all courses the home, the street, and city environment, as contributing to the physical, mental and moral development of the student is made the keynote of the science study.

Following is the outline of the eighth grade work. It is so arranged that both the eighth A and eighth B grades take the same work in the fall and in the spring.

FALL TERM.

I. Personal hygiene (personal hygiene is accented in all grades throughout the year).
  (1) Kinds of soap and how they are made.
  (2) How soap cleanses.
  (3) Use of soap in the laundry—removal of stains.
  (4) Substitutes for soap.
  (5) Soap and a clean skin.
  (6) Tooth pastes and powders.

II. Community sanitation.
  (1) Garbage disposal.
    (a) Receptacles for garbage—kind and care.
    (b) Prevention of flies and odors.
    (c) Collection of garbage—methods and efficiency.
    (d) Methods of garbage disposal—saving of fats.
    (e) Rochester plan.
  (2) Sewage disposal.
    (a) Sanitary plumbing—care and use.
    (b) City sewers.
    (c) Rochester plan.
    (d) Other plans.

III. The heavens.
  (1) The earth and her moon.
  (2) Location of places on the earth by means of latitude and longitude.
  (3) Motions of the earth and their effect.
  (4) Meaning of time on the earth.
  (5) Our sun and his family of planets.
  (6) The stars and the constellations.
  (7) Archimedes, Galileo, and Newton.

IV. Observational work.
  (1) Winter birds—housing and feeding.
  (2) Frost and its effects on the soil.
  (3) Study of a special tree or shrub.
  (4) Wind velocity as well as wind direction.
  (5) Continue observations of outdoor air temperature.
  (6) Planets and designated constellations.
  (7) Seeds and seed dispersal.
  (8) Grasshoppers.
  (9) Examples of conservation as applied to foods, crops, and birds.

SPRING TERM

I. The weather.
  (1) Sayings about the weather.
  (2) Weather factors.
    (a) Temperature—thermometer and its use.
    (b) Winds—direction, velocity, cause.
    (c) Air pressure—how measured; relation to storms.
    (d) Humidity and health.
    (e) Precipitation—clouds, rain, snow, dew, frost.
  (3) Climate in relation to crops, industries, and health.
  (4) Weather predictions.
    (a) Based upon pupils' personal observations of weather facts.
    (b) United States Weather Bureau predictions—how obtained, value.

II. Water.
  (1) Properties, impurities, and uses of water.
  (2) The local water supply.
    (a) The lake sources—altitude, drainage areas, sanitary control.
    (b) Distributing conduits.
    (c) The city's storage reservoirs.
    (d) Boiling water to make it pure.
    (e) Water in the home—faucets, water pipes, traps, meters.
  (3) Purification methods of other cities.
  (4) Vacation dangers in drinking water.
  (5) Chemically pure water.
  (6) Process of distillation applied to gasoline, benzene, kerosene, lubricating oils, and alcohol.

III. Gardening.
  (1) Preparation of the soil.
  (2) Planning the garden.
  (3) Planting the seeds.
  (4) Weeding.
  (5) Marketing.

IV. Observational work.
  (1) Continue daily weather observations.
  (2) Continue work on bird life.
  (3) Flies and mosquitos—relation to health.
  (4) Fire risks in relation to fire insurance.
  (5) Continue the work on the study of common trees.
  (6) Examples of conservation as applied to water supply, liquid fuels.

BERKELEY, CALIFORNIA.

In the Berkeley course of study monograph, the purpose of the course is given thus:

A course in general science should reveal to the pupil the truth about his body and its functions, and charge him with the spirit of investigation towards his own physical well-being.

It should create and foster in him a desire to know more about the simple phenomena that are a part of his everyday experiences.

It should furnish him with useful information which will be of service to him in whatever vocation he may follow, and at the same time increase his power to co-operate in the solution of social and economic problems.

The training which he will get in working projects that deal with food, sanitation, clothing, home building, etc., should increase his physical efficiency, give him a wider outlook toward the life of his home, his neighbors, his country and the entire world, and most important of all, make him a valuable asset to the community to which he belongs.

The plan of the course is geography for the low seventh grade, general science for the high seventh and low eighth, and commercial geography for the high eighth. Many of the topics in the low seventh geography relate to science, as the planets, moon, elements, movements of the earth, seasons, winds, air, water, soil, vegetation, animal kingdom, and modern inventions.

The topics for the high seventh and low eighth grades are: (1) Water and how we use it, (2) Air and how we use it, (3) Heat and how we use it, (4) Light and how we use it, (5) Foods and how we use them, (6) Simple machines, (7) Communication, (8) Transportation, and (9) Man's place in relation to the animal kingdom.

MINNESOTA STATE COURSE.

The makers of the Minnesota course believe:

General science should be organized with reference to the environment and everyday life of the child. In accordance with this, the following principles are suggested as guides in the organization of the subject:

1. The basis for the organization should be found in human life, not in the subject matter.
2. This life should be that of the pupil, not that of the teacher.
3. This should be the pupil's present life, not his future adulthood.

The Minnesota course provides for the use of the project

method by suggesting lists of home projects, school projects, community projects, and field projects.

OAKLAND, CALIFORNIA.

The Oakland course of study for science in the seventh, eighth, and ninth grades has several features that make it superior to any of the other courses mentioned here. The work is outlined by grades, and the outline is detailed, with definite suggestions as to the topics, sub-topics, and class activities for each topic.

At the beginning of each grade's work there are stated the aims of the pupil and the aims of the teacher. An example from the low seventh grade outline will illustrate this:

1. Aims of the pupil.
    - (a) To develop his maximum physical efficiency.
    - (b) To grow certain plants successfully.
    - (c) To clean up plant pests.
    - (d) To raise certain animals for pets or to sell.
    - (e) To get acquainted with some common flowers, trees, and birds.
2. Aims of the teacher.
    - (a) To develop an appreciation of the fundamental relation of the green plant to food, clothing, shelter, and fuel.
    - (b) To develop an appreciation of the farmer's job; its dignity, its difficulties, and its fundamental importance.
    - (c) To show that faithful observance of health habits yields dividends of growth, strength, and happiness.
    - (d) To teach the life processes of plants and animals.

The work is divided into units, and for each unit there is a list of "Standards of Attainment." This list is divided into "Skills" and "Knowledge." The following are the Standards of Attainment for the topic in the low eighth grade, "Sanitary handling of foods in the kitchen."

1. Skills.
    - (a) To keep milk and butter under the most favorable conditions.
    - (b) To distinguish fresh from stale eggs.
    - (c) To protect food from mold and fermentation.
    - (d) To keep raw foods clean.
2. Knowledge.
    - (a) To know the reasons for keeping milk covered, cool, and dark.
    - (b) To know what constitutes a pure milk supply.
    - (c) To know what is meant by pastuerization.
    - (d) To know how to prevent poison from botulism.

The topics considered by grades are:

Low seventh:

1. Seasonal nature study.
2. The growing plant.
3. The growing child.
4. Fall work in the garden.
5. Potted plants and window boxes; bulbs.
6. Plant enemies.
7. Growing animals for pets and food.

High seventh:

1. Keeping animals healthy.
2. Planning and planting the garden.
3. Care of the garden.
4. How a plant provides for the future.
5. How animals develop.
6. Keeping children healthy.

Low eighth:

1. Seasonal nature study.
2. Heating and ventilating the home.
3. Making the kitchen a good working laboratory.
4. Sanitary handling of foods in the home.
5. Mineral products used in the home.

High eighth:

1. How electrical discoveries and inventions have changed living conditions.
2. How science aids in preventing accidents and treating the injured.
3. How science has shown the efficient way to control the human machine.
4. The baby's care and growth.

Low ninth:

1. Introduction to the study of science.
2. Earth's history and relation to other heavenly bodies.
3. Weather and air.
4. Water supply and sewage disposal.
5. Bacteria and communicable diseases.
6. Scientific principles involved in transportation.
7. Seasonal nature study .
8. Current events in science.

High ninth:

1. Seasonal nature study.
2. Current events in science.
3. Lighting.
4. Pure foods.

5. Patent medicines.
6. Foods in relation to the human body.
7. The living world.
8. Kinship of living things.
9. Improvement of living things.
10. Photography.
11. Sound in its common aspects.

In writing of the course in an article in the University High School Journal, for October, 1921, Dr. Bailey, the supervisor of science, writes:

The organization of this material was determined by asking the following questions: (1) What is feasible, considering the limitations due to large classes, scanty equipment, and narrow training of science teachers? (2) What material can these boys and girls use, either in practical application to situations in which they find themselves, or in intellectual application to the task of understanding the world in which they live?

In answering these questions we have been guided by our first-hand knowledge of the pupils' interests, hobbies, and responsibilities. The average youngster has too few hobbies and far too few responsibilities. In consequence, his interests tend to become futile, rather than fruitful. Recognizing this, an effort has been made to give preference to material which can be expressed in the form of something to do, worth doing because it results in tangible accomplishment of social worth.

In the first two years' work this effort has been fairly consistent; most of the material considered can be turned to account by the pupil at once. This was possible because the work in those years had been more fully developed, and because junior high school teachers are not so noticeably subject-minded and are more fully awake to the working of a youngster's mind. A seventh-grader presents a difficult and distasteful problem to the teacher who is thinking more of science than of boys.

The instructions issued to Oakland curriculum committees require a brief justification for the course, a reason for its holding a place in a school day already overcrowded. The General Science Committee sets forth the faith that is in them as follows:

"This committee feel that the best justification for the course offered herewith is two-fold:

(1) The topics chosen speak for themselves, embodying interests which are common, vital and compelling for all of us, because we are human beings living in a civilized community.

(2) The work, as tried out during the last three years, has proved itself the sort of thing that Oakland children like to do and do well. Even under many handicaps the co-operation of classes has been most encouraging and stimulating to all those who have

worked with them. In a sense this outline is the work of Oakland boys and girls, quite as much as that of Oakland teachers.

The material presented is selected for its social and practical values, and yet is commonplace, so that the everyday things may stand revealed as the wonders they really are."[9]

This study of the status of science in the junior high schools brings out the fact that while well-developed courses are being given in many places, school systems still differ widely as to the amount and kind of science instruction. There should be greater continuity of the course through the elementary grades and into the senior high school. Thus we come again to the problem of the thesis—the need of making a course of study in junior high school science, and the desirability of using the objectives of science teaching as determining factors in making such a course.

V.

MAKING THE COURSE OF STUDY.

The second Yearbook of the Department of Superintendence of the National Educational Association, published in 1924, is concerned exclusively with a report of a study of the school curriculum. This report gives a very thorough presentation of the present status of curriculum-making and curricula in the schools, and together with the works of Charters, Hines, Bobbitt, Bonser, and others, has been used as source material for the review of the subject given here.

THE QUESTIONS TO BE CONSIDERED.

a. *Whom does the curriculum concern?* One of the first things to be considered, according to the 1924 Yearbook is the question: With whom is the curriculum concerned? It deals first of all with the child. It is the varying types of children, their individual differences, their emotional, social, and intellectual lives that need to be taken as the basis for curriculum-construction.[10] This means that the course of study must be differentiated to meet the varying needs of the pupils.

9 Bailey, Edna W. Science in the Junior High School. University High School Journal, vol. 1, Oct. 1921, p. 181.

10. Journal of the National Education Association Editorial, Feb. 1924, v. 13, p. 69.

Johnston states that there are four groups of pupils in the junior high school for which provision must be made in the curricula. These are, (1) those who will go to college, (2) those who desire a general liberal arts training, but will not go to college, (3) those who will take vocational courses in senior high school, and (4) those who will not go to senior high school.[11] The course of study in science should contain material for each of these groups. It must be wide enough to give the child who will have no further education a foundation of necessary scientific facts and an interest that will keep him investigating for himself; it must be specialized for those groups who need vocational training.

Second the curriculum concerns the teacher. She must understand its aims and purposes and with the aid of supervisors make it "a living thing for a group of rioting youngsters."[12]

The curriculum also concerns the parent, who is beginning to examine closely into what his child is being taught at school; the community which wants to know the exact purposes of its schools; the tax-payer, who wants to know what his money does for the children of the community; the enthusiast who wants new and special ideas tried out in the schools; the nation, which demands a satisfactory education for its citizens; and the next generation whose welfare depends on how well the children of today are prepared to become the parents of tomorrow.

b. *What are the aims and objectives of education?* This has been answered for this thesis in the sections on the nature of the junior high school and the nature of science instruction in the junior high school.

c. *What are the purposes of the course of study?* This is answered by Margaret M. Alltucker, summarizing the material of the Department of Superintendence Yearbook for 1924:[13]

(1) To guide the teacher in her work. The printed course of study is her handbook. It should help her to understand the purpose of school work—what things to teach in each subject and how to divide the time. In so far as it limits and restricts the individual expression of the thoughtful teacher it is at fault, in so far as it aids the work and gives ample latitude to the strong it is help-

11. Johnston, C. H. and others, Junior-Senior High School Administration, p. 182.

12. Journal N. E. A. v. 13, p. 69.

13. Alltucker, Margaret M. Building the Curriculum Journal N. E. A. v. 13, p. 67, Feb. 1924.

ful and worth while. As a guide it should encourage initiative and resourcefulness and inspire the teacher to her best thinking.

(2) To co-ordinate all the effort of the school, to unify the work of the various grades as to aims and principles, and to enable each teacher to see her own work, not as a separate unit, but as growing out of the work of the preceeding grades, and leading to that which is to follow.

(3) To provide a basis for classification and promotion, to make approximate assignments of work to be completed within given periods and to establish standards of attainment which will help each teacher to keep in mind certain facts, habits, and skills which children in her class are expected to acquire, with ability to use these in situations requiring their use.

(4) To encourage teachers to keep in mind the fostering of superior abilities with which some of the children are endowed, and to help all children to work to their capacity.

(5) To encourage teachers constantly to work toward the realization of those ultimate, though less tangible aims, namely: the cultivation, as by products of all the required work, of certain habits, skills, interests, attitudes, appreciations, and ideals which promote not only the ability to make a living, but the ability to live abundantly.

d. *What are the essentials of a course of study?* The course of study should consist of pupil activities arranged to suit the group for which it is planned and embodying the aims of education and the purpose of the particular subject. It should consist of material that will develop the desired knowledges and skills, habits, interests, and attitudes. Again quoting Margaret M. Alltucker:

"In brief, the essentials of a course of study are: statements of general educational aims and objectives, aims of particular subject courses and their relationship to the general purposes of education, outlines of pupil activities, subject course references for both teacher and pupils, grade outcomes, and differentiation of material to fit pupils of different levels of ability as well as standards of attainment measured by educational tests."

e. *Who shall make a course of study and how?* Ernest Horn said, "The best course of study in any subject is possible only by pooling the leadership in that subject."[14] This means that class room teachers, supervisors, superintendents, research experts, and normal and college teachers must collaborate in the making, if the course of study is to develop into well-rounded whole. The how of the question will be considered under the

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14. Department of Superintendence of N. E. A. Yearbook, 1924.

next two headings; organization of the group, and steps in procedure.

ORGANIZATION OF THE COURSE OF STUDY-MAKING GROUP.

Before organizing the group that is to make the course of study in junior high school science, the administration should investigate the practices of other cities that have undertaken such a project and learn how and with what success it was carried to completion.

In Chicago, the president of the Chicago Principals Club appointed a Course of Study Committee. This committee organized special groups to consider special subjects of the curriculum. The special group for each different subject made a thorough study of the subject and frequently extended its membership to include persons who were special authorities in the given subject. Each point of the course regarding policy, procedure or subject content was carefully criticised in the light of most exhaustive educational research. The completed reports were submitted to the superintendent for his approval and when approved were issued through the superintendent's office.[15]

The committee for making the course of study for junior high school science should be made up largely of teachers who have had experience in the subject, or who are teaching it and are willing to try out the various points agreed upon in their classes. There should also be on the committee teachers of specialized sciences, who can aid by their suggestions as to what should be included or omitted from the junior high school course. Teachers of nature study, or health, or any other subjects related to science in the lower grades should also be consulted in order that the final science course shall be a proper link between the science of the elementary schools and that of the senior high schools. Supervisors of science instruction should be included in the group and whenever possible the entire procedure should be in the hands of an expert who has made a special study of curriculum construction.

Franklin K. Bobbitt, professor of Educational Administration at the University of Chicago, was at the head of the recent curriculum investigation in Los Angeles. His book "How to Make a Curriculum," gives an account of the procedure there

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15. Guthrie, May G. The Work of the Course of Study Committee of the Chicago Principals' Club. School and Society, vol. 19, Feb. 2, 1924, p. 132.

and will be a helpful source of suggestions for any course of study group. W. W. Charters' "Curriculum Construction" is another book with which the group should be familiar.

Bobbitt particularly stresses the point that each curriculum-making group should do its own thinking and not take its thought second-hand. Also he calls attention to the fact that courses of study need to be made for use in the near future, within the next year or two perhaps, but it must be kept in mind that curriculum improvement is a generation-long labor, the result of many small improvements that are made year by year.

STEPS IN PROCEDURE.

Tracing the ideas that have been held concerning curricula during the last thirty or forty years shows the exact sort of educational situation that the curriculum-makers face today.

a. *Subject matter analysis.* In 1892-93 the Committee of Ten, of the National Education Association, made their studies and report. Life had been growing more complicated and the courses of study given in secondary schools were growing more numerous and diverse. Schools over the entire country did not agree as to the subjects taught or the methods used. These were largely a matter of personal choice on the part of the instructors. The idea brought out in the report was that through methods inherent in the subject-matter itself, certain powers could be developed that would be useful to the individual and would prepare for college and for life. The course of study was to be made as the result of a subject-matter analysis, and they set down a group of principles concerning the amount of time to be devoted to a subject, the sequence of subjects, the year of high school in which a subject should be taught, and recommended, that by the end of the tenth year the student should have entered all the principal fields of knowledge.

b. *Activity analysis.* The idea of subject-matter as the basis for educational practice was adopted and held for several years, but gradually following the thinking of De Garmo and Bagley, came Franklin K. Bobbitt with the idea that educative values are not inherent in subject-matter, but in the activity of the individual. He said that the objective of the curriculum are activities in which people engage, and they can be discovered by an analysis of the world of affairs. The activity of the individual is not always on the high plane that it should be and

often the activity of the individual falls short of the activity of society, but by finding where these activities are deficient, the school can provide the training necessary to prepare the individual to take his place in society. Certain activities are the objectives of education and the curriculum of the schools consists in giving the child the experience which he must have for the successful performance of these activities. Then the subjects selected are the means by which the proper activities, such as health, vocation, citizenship, and so on, may be realized.

Later Charters added to Bobbitt's "activities" certain ideals. Good citizenship should mean not only the performance of certain activities, but the holding of certain ideals which accompany those activities. Ideals may be taken as a starting point and through them the activities may be developed, or activities may be selected and the ideals taught through the activities, but both must be taken into account in making the course of study.

c. *Functional analysis.* Charters develops the thesis that the curriculum can be built by functional analysis, that is, finding those things which have a special function in the life of the individual. He distinguishes between "duty analysis" "difficulty analysis." Duty analysis produces a list of duties or operations which one has to perform in a certain line of activity, while difficulty analysis includes those operations which offer difficulty to the pupil and which therefore must be emphasized in the curriculum.

d. *Project curricula.* Still another view of the curriculum is that it is a series of experiences or projects which must develop (1) knowledge and information, (2) habits and attitudes, and (3) appreciations. In working out the projects, subject-matter must be used to furnish facts and processes by which the activity may be carried on and the project must be organized and discussed in such a way that it will develop methods, skills, ideals, attitudes, and appreciations. The project must be graded according to the interests and capacities of the child and selected on the basis of the activities and interests of the children. In this method of determining the curriculum, which is advocated by Margaret Wells, Bonser, and Collings, (see bibliography) experts, teachers, and children, all have a hand in the making of the curriculum.

e. *Summary of steps.* Charters' summary of rules for curriculum making may prove helpful as a guide for a course of

study making group, although no one set of rules should be adopted, but the committee should determine its own rules in the light of its own particular problem.[16]

1. Determine the major objectives of education by a study of the life of man in its social setting.
2. Analyze these objectives into ideals and activities and continue the analysis to the level of working units.
3. Arrange these in the order of importance.
4. Raise to positions of higher order in this list those ideals and activities which are high in value for children, but low in value for adults.
5. Determine the number of the most important items of the resulting list that can be handled in the time allotted to school education, after deduction those that are better learned outside of school.
6. Collect the best practices of the race in handling these ideals and activities.
7. Arrange the materials so obtained in proper instructional order, according to the psychological nature of children.

A more recent book on the subject, and one the course of study committee will find very fruitful is Phillip W. L. Cox's "Curriculum Adjustment in Secondary Schools." This book, as well as Clement's "Curriculum Making in Secondary Schools," summarizes the work that has been done in the field. They are valuable to refer to for condensed information and summaries. Cox's book contains a bibliography with a short critical comment on each book listed. This procedure makes the bibliography exceptionally usable. The works of Charters, Bobbitt, Bonser, and Collings, on the other hand, give the thesis developed by them. Each man brings his own particular contribution to the subject of curriculum making.

Having analyzed the purposes and essential features of a course of study, and set forth the best practices at the present time, in making courses of study, the final work of the thesis will be to show how the knowledge gained, may be used in the actual building up of a course of study. Material has been presented showing the nature of the school in which the course is to be used and the kind of course that seems most desirable. General tendencies in elementary science instruction have been noted and outlines given of courses actually in use. All this is fundamental to the problem of making a course of study in junior high school science.

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16. Charters, W. W. Curriculum Construction, p. 102.

(*To be continued.*)

Are Test-Tube and Microscope Final?

Pity for the man or woman who maintains such a materialistic view of life as to accept as the final solution of its mystery only what he sees in the test-tube or through the microscope, was expressed by Dr. Allan Craig of Chicago, in an address delivered recently before the American College of Surgeons, meeting in Montreal. "It is the spirit within him that makes the man supreme in the world and allows him to control materialistic things," said Dr. Craig, who is an associate director of the College of Surgeons. "Medical science and religion are complementary to each other." Describing the chemical constituents of the human body, Dr. Craig said:

"Consider the average 150-pound body of a man from its chemical aspect. It contains lime enough to whitewash a fair-sized chicken-coop, sugar enough to fill a small shaker, iron to make a tenpenny nail, plus water. The total value of these ingredients is ninety-eight cents, or about sixty cents a hundred-weight on the hoof. Yet the insurance companies place the economic value of a man at $5000. How do they account for the difference of $4999.02?"

The answer, he said, was in the value of the spirit within the man. Discussing the relation of medical science and religion, he said:

"The churches of today must come out of the clouds. The people of today are not irreligious. But our young people are not interested in fundamentalism or the higher criticism. They care little about Lot's pillar-of-salt wife, or Jonah's escape from the interior of the whale. The young people are interested in clean living and moral precepts as laid down in the Ten Commandments. Medical science is just as much interested in the observation of the Ten Commandments as are the churches."

More and more, scientists worthy of the name are taking the position to which Dr. Craig gave expression. A new day is dawning, when the spirit of man will once more come into its own.—*Zion Herald.*

Individual Laboratory Work *versus* Teacher Demonstration *

By Eliot R. Downing, University of Chicago.

The purpose of this paper is to present the results of a series of eleven experimental studies that have been made on the relative value of individual laboratory work by the student and demonstration from the teacher's desk. Several years ago it occurred to the author that while we were teaching science generally by the laboratory method, we had no proofs of its superiority. This method of instruction is a fairly recent innovation in science teaching. Liebig's laboratory at Giessen, opened in 1824, was the first to offer such instruction to students, and these students were preparing for chemical investigations. In 1836 the chemical laboratory of the medical school at the University of Pennsylvania was open to students, but this was in no sense a student laboratory. It was the laboratory of the professor of chemistry, which he put at the disposal of promising students, who could devise their own experiments and conduct them without supervision. Agassiz' laboratory at Lawrence Scientific School, later incorporated in Harvard University, was an old boathouse on the banks of the Charles River, where he permitted some of his students to work on their research problems. This was about the middle of the last century. Pickering opened a laboratory in physics to students at the Massachusetts Institute of Technology in 1868.

In 1880 the United States Bureau of Education sent out a questionnaire to the high schools of the country, in regard to the teaching of physics. Slightly over six hundred high schools replied. Of these, four hundred were not giving courses in physics. Only four were teaching physics by the laboratory method. Some fifty were using demonstration by the teacher, and one hundred and fifty were still teaching by the book method, pure and simple. It was not until Harvard, in 1886, prescribed a number of experiments in physics which

* Paper presented at General Science Section of meeting of Central association of Science and Mathematics, Chicago, Nov. 26, 1926.

must be done by students who presented physics for entrance to the University, that laboratories in secondary schools began to appear with considerable rapidity.

It is evident then, that science has been taught for many years by the book method only, then by the demonstration method, and only recently has the laboratory method appeared. Judging by the scientific achievements of the men who received their training in science in the early schools, the book and demonstration methods were reasonably successful.

Several years ago, when a graduate student in the Department of the Teaching of Science, the University of Chicago, desired a thesis subject, he was started on an experimental investigation of the demonstration method and the individual student laboratory method. His results, contrary to expectations, showed the demonstration method to be superior in the immediate tests, and only slightly inferior in the delayed tests. Since the ome was contradictory to his training and habits of teaching, he decided to report the experiments. A second graduate student was also started on the same problem, and later a third. Both of these men also reported their experiments; in addition, five other investigations have been made on the same problem, and in every case the findings of the first investigation have been confirmed.*

The method of procedure in these experiments has been to give the pupils one or more mental ability tests, and on the basis of these tests and their previous school grades in science to place them in two or more sections. Two students whose averages were nearly identical would be put, one into one section, one into the other. In this way the sections were equalized as nearly as possible. Sometimes there would have to be included students who could not thus be paired, but while they were carried in the class, they were not made a part of the investigation. A number of experiments were then conducted, one section having the experimental work in the laboratory where the individual students performed the experiments, the other section seeing the experiments performed by the teacher. The notebooks used, the readings assigned, were identical in the two sections. The teacher memorized

* For details of the experiments so far published, see an article by the author in School Review, XXXII, 688-697, Nov. 1925.

the laboratory directions that were given to the students, and in his demonstration used the identical language, with, of course, the necessary change in the personal pronoun. After each experiment, identical tests were given to the two sections, and after a period of several weeks or months, another test, identical in the two sections, was given on each experiment. No discussion was permitted, either in the laboratory or in the classroom. It is evident then, that the laboratory methods here used are neither of the types customarily in vogue, but since such questions and discussions could not be kept uniform in the two sections, they were ruled out. The one variable factor to be tested, then, is the student's own conduct of his experiment in contrast with the conduct of the experiment by the instructor.

These experiments show that on the immediate tests, the information has been acquired by the student quite as well by the demonstration method as by the individual laboratory method. On the delayed tests, the laboratory method makes a better showing, and the longer the test is delayed the greater the difference in favor of the laboratory method. But when the write-up of the experiment in the test is subdivided into, first, what was the purpose of the experiments; second, how was the apparatus set up; third, what happened in the experiment; fourth, what does the experiment prove,—it is found that the superiority of the laboratory method is due to the fact that students remember better the third and fourth points. Even on the delayed tests, the students comprehend the purpose of the experiment quite as well by the demonstration method as by the laboratory method, and they make a much better showing on the fourth point, the conclusions to be drawn from the experiment. Since it is the purpose and the conclusions that are important, and not the manipulatory details, it must be concluded that the demonstration method is superior, even on delayed tests.

Some of the investigations seem to show that even laboratory skills, at least in their initial stages, are better acquired by demonstration than by individual laboratory work. That is not as surprising as it at first appears, when it is remembered that initial skills are best obtained by imitation rather than by one's own blundering efforts. Some of the investigations have also been addressed to the determination of the merits of the

two methods in preparing students to attack and solve problems, and again the demonstration method gives superior results. More investigations are needed, however, to confirm these tentative results.

There is marked saving, both in time and expense, by the use of the demonstration method. The time-saving varies in the various investigations, the highest being 50 per cent. In one investigation it was found that the expense of teaching a class of thirty in chemistry by the demonstration method was 1-16th of that for the companion section in the laboratory. These figures deal only with the current expenses and do not take into consideration the initial equipment.

The laboratory is primarily a place for acquiring experience. If, however, the pupil can see what is going on on the teacher's desk, can hear or smell the results of an experiment performed at the teacher's desk, it would appear that he is acquiring his experiences quite as well as he would if the experiment were on his individual laboratory desk. Furthermore, the teacher who is conducting the experiment can, by proper questions, make sure that his pupils know what apparatus is being used, how it is set up, what substances enter into the experiment, what the experiment is for, and what conclusions are to be drawn from it. He cannot make certain in the laboratory that his students are aware of all these items, for he does not have time to go from desk to desk to quiz all pupils on these matters.

Certainly the results of these experiments must give us pause in the advocacy of the laboratory method as the only method by means of which secondary school science can be effectively taught. Until they are contradicted by further experimental evidence, and that seems very doubtful in view of their extent, the science teacher may well give a large part of his instruction by the demonstration method. It is interesting to note in this connection, that in European secondary schools the science is as a rule taught by the demonstration method, except in the case of those students who know that they are going into some vocation in which they will need the laboratory skill. In that case, such pupils are put into prevocational secondary schools and have their science by the laboratory method.

Creating Interest in General Science

By J. A. Ernest Zimmermann, Training Instructor and Critic Teacher, State Normal School, Shippensburg, Pa.

The interest for the study of General Science in the classroom may be considerably increased by providing the proper setting and background in pre-developed lesson plans. For the last few years psychologists and educators have proclaimed as an introduction to a lesson: "Create an attitude of mind favorable to your lesson." Teachers usually ask questions on an assigned topic which in reality should be a problem for the boy and girl to solve. A lesson of light is usually introduced: "What is light?" or "What have you studied about light?" The author has always checked the student-teachers of the Junior High School Department of the Normal School very closely to have a proper background or setting applied on the introduction of a new problem in science. The following illustration has always had the desired effect for results: "How would a stage production, requiring an outdoor scene, appear to you if the rostrum were devoid of all properties and only bare walls and brick greeted your eyes? Would you enjoy such a play without the proper back ground or setting?" The answers have always been in the negative, which was an opportunity for them to realize the importance of the proper "setting."

Having them in such a psychological state of mind they could readily understand that such a production lost its effect and significance at the beginning, since one had to get his bearing before being able to enter into the spirit of the "play," before the mind grasps the situation and can participate in the ideas of the producer. Yet how many teachers do this very thing? Repeatedly the lessons are devoid of this "setting," this background. The child becomes bewildered and gropes until he finds his bearing. By the time he seems to have found a solution from his entanglement the greater part of the time has been consumed, he is dismissed, and passes to his next class, losing that which he did not grasp during the maze through which he passed. The author has been very for-

tunate, during his seven years' experience, to get this setting in various ways. This is possibly best illustrated by a concrete problem. Introducing a problem, as light, it has been his custom to have every boy and girl look about himself in the room or outside the windows and note things of interest to them on a sheet of paper. Several members of the class are then requested to read their notations, from which the following questions arise:

Question: How did you know the birds were in the tree?

Answer: I saw them.

Question: Why did you see them?

Answer: I looked at them.

Question: How did you see them?

Answer: With my eyes.

Question: What caused you to see them with your eyes?

Answer (This varies according to the following): The mind and nerves, through the lens, or, The vision is implanted in the eye and the lens sends it to the brain with the retina, or The light is reflected on the eye that sends it to the brain.

(All these answers, and others, were obtained, as given, from the boys and girls in the Junior High School Department during the year 1925-26.)

At this point, one of several threads may be taken up with discussion relating to light, or the eye may be chosen as the basis for the discussion. If the problem of light is to be the work, several ways may be used in order to arrive at the question, "What is light?" For instance:

Question: What caused the image to be impressed upon the mind by means of the eye? or, What caused this image, you say goes to the mind through the lens of the eye?

Answer: The light causes the eye to see, or, The light strikes the eye and the lens permits us to see.

Question: You say the light permits you to see. What is this light?

Answer: It is something we get from the sun.

At this point the abstract idea may be introduced, and the pupils may be led to discover that it is vibratory motion, that light has speed, it travels in straight lines, etc.

However, it is more advisable to study the eye, and by this means lead to lenses and their uses, to the camera, and then

the abstract ideas of light. This method is more vivid to minds of boys and girls than the former, and they do not lose interest, particularly if the picture of the group is taken and developed and finished where they may observe the process, when they discuss the problem of the camera. A lesson plan conforming to the above procedure is appended for a clearer explanation.

Another novel idea, introduced by the author several years ago, while teaching in the schools of New Jersey, was "Question Box Day." This has always aroused, and does arouse, a great deal of enthusiasm and interest among the pupils. The idea has been carried out for a number of years.

One period a week was set aside for this work, which consisted in the discussion and answering of questions submitted in writing by the pupils. These questions had to be in the hands of the instructor at least a day or two previous to "Question Box Day." This not only gave the opportunity to cast aside irrelevant questions, but also to obtain necessary information if it was needed.

There are always problems in the minds of the boys and girls at this age. They are living question marks, and should have their little questions answered, since they do not always know where to locate the desired information. It is remarkable what the boys and girls learned from these discussions; because they were their problems they entered into it wholeheartedly and took part as well as a great deal of interest. These questions that were presented had no solution in their text-books, but they were vital to them. In order to show the nature of the questions, a few have been appended:

Do rocks grow? If they grow, how do they grow; if not, why not?

How does a photographer enlarge pictures?

What causes the heart to beat?

What causes the radio to play?

How is the record of the Victrola made?

How can the ear hear?

What causes the hand and foot to go asleep?

What causes the Victrola to play?

What is gunpowder composed of?

What is phosphorus made of?

What causes the needle to play a record?

How is the colored fire of the Fourth of July made?

From this it can be readily understood the nature of interest manifested. The boys and girls never enjoy anything better than those things that seem a real problem to them, things that seem to appeal and have a mystery about them.

LESSON PLAN ON LIGHT.

I. Problem: Light and its nature.

II. Teacher's Aim: To have boys and girls become acquainted with the nature of light and its actions.

III. Topical Outline: Introduction (setting); The eye and camera; Lenses, action, use and properties.

IV. Apparatus: Bull eye, cameras and Kodaks, lenses, candles and lights.

I. *Subject-Matter.*	I. *Method (Procedure).*
A. Create an attitude of mind favorable to the lesson. Birds, barometer, desks, girls, books, etc. (The mind and nerves through the lens, etc.) (The light strikes the eye and the lens permits us to see.)	A. Introduction: Note a few things on paper, either in the room or outside the window. Read them. How did you know the birds were in the trees? Why did you see them? How did you see them? What caused you to see them? (Answers vary greatly at this point.) What causes this image, you say goes to the mind through the lens of the eye?
B. The eye. Highly specialized organ of sense. (Have bull eye or any other form of eye for dissection to show the various parts, and have the work performed from this.)	B. You say the eye permits us to see. What is this eye? I have an eye here I shall cut into half crosswise, then we will diagram the parts on the board and find names for them. (Let some one make a diagram of the cross-section and have them find the names in the science book and place the terms at their respective places on the diagram.) Having this diagram, let us learn the use of the various parts.
1. Optic nerve.	1. What is the optic nerve? What does it do for the eye? How does it do that? What form of an image do we find on the retina? (Inverted. This is to be shown by mounting the lens and showing the image of a candle on a screen.)

2. Retina.	2. What is the retina? What does it do for the eye? How does it transmit the image to the optic nerve? If the image is inverted, how then, can we see the thing in its right position? What is the color of the retina?
3. Vitreous humor.	3. What purpose does the vitreous humor serve the eye? What kind of material do you find it to be?
4. The lens. (Mount and show image formed.)	4. How does the lens compare with the vitreous humor? What is the purpose of the lens? We will mount it and see what form of an image it forms. What and how do you see this image? Why is it inverted? (It is best to inform the pupils that the lenses will be studied next and the reasons for inversion; however, a great variety of answers will result.)
5. The iris. (Diaphragm.) Muscles.	5. What do we find before the lens? What is the purpose of this iris? How does the iris permit only some light to enter? What causes it to become larger or smaller.
6. The aqueous humor.	6. What do we find before the diaphragm and lens? How does this compare with the vitreous humor, the lens and the retina? Why is it there?
7. The cornea.	7. What is the bulging part before the lens and the colored part of the eye? What does it do for the eye?
8. The pupil.	8. What is the pupil of the eye? How is it formed? What is the size of it? (Have them look at each other's eyes and observe the change in the pupil by changing the vision from close to far-off objects.) What causes the color of the eye?
9. Sclerotic coat.	9. What is the sclerotic coat? What does it do for the eye? In what way does it serve as a protection?

V. Conclusion. Check these facts the following day and begin the work on the camera. Have several photographs at your command, and pass them to the various members, afterwards asking what they are. Inquire how they were made, and proceed to get a description of the camera. Have several Kodaks and cameras at hand. After the description of the construction, invite the group outdoors, take a photograph of them and develop it in their presence, making the prints the following day. From this it is very easy to lead to the subject of lenses, and then the abstract ideas and speed of light. Have them compare the eye with the camera as a review of the two.

Why Airplanes Go Up

By O. E. Underhill,

Lincoln School of Teachers College, New York City.

John. How can an airplane stay up in the air?

Mary. Why the air holds it up.

John. But the flying-machine is heavier than the air.

Mary. Iron ships are heavier than water, but they float. You remember the teacher told us how the ship is pushed by the water and how the amount of water displaced determined how the ship floated. And about Archimedes jumping out of the bath-tub when he found out how to tell if the king's crown was pure gold.

John. Yes, I remember that; but I don't think this is the same. Balloons go up because they displace air the same as a ship displaces water. I don't think airplanes are like that, because they are lots heavier than balloons and not nearly so big. The dirigibles, like the Shenandoah and the Los Angeles, are like a ship in water.

Charles. Here comes the teacher—ask him.

John. Sir, how does an airplane keep up in the air, when it is so heavy and yet doesn't displace much air?

Teacher. Did you ever fly a kite, John?

John. Yes, sometimes I have.

Teacher. What makes it go up?

John. The wind.

Teacher. Can you sail a kite without a string?

John. I never tried it. I have had my string break and the kite go off, so I should think it would.

Teacher. I think you had better try a little kite flying before I answer your question. Suppose you all try your hand at making a kite. See which one of you will make the kite that will fly the best. Today is Friday. You might try it tomorrow, and next week tell me what luck you have.

* * * * * *

Teacher. Well, how did your kite-flying venture come out?

John. Charles' kite flew the highest, but mine went nearly as high.

Charles. I tried tossing mine in the air without any string, and it wouldn't go up at all. If it was only a little way up and I let the string out very rapidly it most always came down edgewise, but if I pulled on the string with little jerks it would go up again.

Teacher. That is one thing I wanted you to find out. The string is needed for another reason than to keep the kite from getting away.

Mary. I let go the end of my string and the kite kept on going and I couldn't get it again.

Teacher. Yes, Mary, that might happen. If the string is very long its own weight makes it pull on the kite to some extent, just as if you had it in your hand. Did the kite go up any further?

Mary. It did a little, and then it dived and bobbed up and down, and blew away very fast, and finally dived into some trees.

Teacher. You see your kite didn't go up much after the string broke. It traveled along with the air currents. If the air swerved upward for awhile your kite might go with it, but it wouldn't climb up on the wind the way it does when you have hold of the string. It just blows around like a leaf or a shingle and finally turns edgewise to the wind and comes down. Charles, how did you make your kite so it would fly so high?

Charles. I took a light stick about three feet long and put a cross stick about two feet long two-thirds of the way up the long one. Then I put a piece of cord around the edge and covered it with paper. I tied strings to the four ends of the sticks and fastened my kite string to them so it would hang at a slant. At first John's kite went better than mine, but I changed the strings so mine slanted at a little different angle, and it went better. I had quite a long tail made of short pieces of rags tied into a string.

Teacher. Wouldn't the tail make it heavier, so it wouldn't go so well?

Charles. Oh, no. You have to have a tail.

Florence. I tried to send one up without a tail, and it kept pitching and tossing from side to side and wouldn't stay up.

Teacher. We have found three things, then, that influence the flying of the kite: the pull on the string, the slant, and the tail. You see, the wind blows against the slanting surface of the kite and tries to blow it along, but the string holds it from blowing away with the wind, so the wind slips along under the slanting surface of the kite and gives it a push up and forward. The kite string won't let it go forward but it can go up. The weight of the tail holds the lower end down and steadies the kite, so it doesn't flop around in the wind and swing so much. Here is a picture of what happens. (*Draw on board.*) The wind is striking the kite in this direction. (*Point.*) As the surface of the kite is at an angle to it, part of the force of the wind tries to push it ahead and part upward. The string will not let it go ahead, so it moves up. The pull of gravity is pulling the kite down, so it will move to a point where the upward push of the wind is equal to the weight of the kite. When you run you make the wind strike the kite harder, and it goes up higher. It has the same effect as if you made the wind blow harder. Has anyone ever seen a kite without a tail that would fly?

Florence. A box kite hasn't any tail.

Teacher. Right. Because of its shape and the angle at which it is held by the string attached to it, a box kite will hold its position to the wind without a tail. Now what would you have to do to a box kite to make it into an airplane?

Charles. Put an engine and a propeller on it.

Teacher. What does the propeller do?

Mary. It blows the airplane along.

Teacher. I am afraid that is not quite it, Mary. Let us think a little about what an airplane without a propeller would do. Men tried to fly with wing-like planes before motors were invented.[1] They used to jump off high places with these machines and travel a long way, but as they had no motors they could not get up into the air again. Take your blotter out from your desk. Hold it level just by the tips of the

1. A good place to have a topic or two presented to the class by one or two of the pupils on the history of the development of the airplane.

corners about four feet from the floor, and let it fall. . . . How does it fall?

Alice. It falls straight down to the floor.

Teacher. Now hold it as high as you can and tilt it forward a bit as you drop it.

Alice. Mine turned over.

John. Mine turned over three or four times.

Mary. Mine did too.

Charles. And mine.

Teacher. When the blotter slants the air is pressing up on the front edge and the weight of the blotter is pulling down near the center; so it flops over, and once started often keeps on turning. This is what happens to an aviator sometimes. Something goes wrong or a sudden gust of wind is struck which pushes one end of the plane up, and it turns over and over as it falls. Now bend the blotter just a little in the center and near one edge, so as to make a crease. Here is a box of paper-clips. Slip a clip on the blotter at the crease. Now hold it over your head and drop it.

Charles. It's just like a toy glider.

Teacher. The weight of the paper clip balances the weight of the blotter, so that it doesn't turn over. See who can make theirs fly the farthest.

John. Mine goes almost all the way across the room.

Teacher. You see that they can only glide downward on the resistance of the air. An airplane can pull itself up on the air, and that is where the motor and propeller come in. The propeller is turned very rapidly by the motor. It cuts through the air, and because it twists like a screw, pulls the airplane after it. The wings of the plane are slanted against the wind like a kite is, and therefore there is an upward thrust against them. Now, if the propeller pulls the airplane through the air at a speed of a hundred miles an hour it is striking against the air just as if the wind were blowing a hundred miles an hour. You remember what the hurricane blowing one hundred and thirty miles an hour did to Miami and the surrounding country last September? (1926) So the airplane goes up because the upthrust of the air is equal to the weight of the airplane, just as the kite does when the air strikes it. Airplanes must maintain a speed of sixty miles an hour or

more in order to strike the air hard enough to be lifted by it. Its direction is maintained by a rudder, the same as in a boat, and it may be directed up or down by blades or vanes on the tail, which cause the pressure of the wind to elevate or depress it and thus head the whole plane upward or downward.

Perhaps you would like to make a simple model airplane or glider, or a "high-flyer." If you would like to, come to me after class and I will tell you where to find directions.[2]

Robert A. Millikan, Physicist

To the scientific world Robert A. Millikan is well known, as Director of the Norman Bridge Laboratory at California Institute of Technology, as winner of the Nobel prize in physics in 1923, as the isolator and measurer of the electron, and more recently for his work on the "cosmic ray." To educational circles he has also made a contribution. Hand in hand with his experimentation has gone the translation of his researches into a form and language understandable to pupils in the secondary schools. Many teachers identify Dr. Millikan more readily as the co-author of "Practical Physics" and of the newly-published "Elements of Physics," than as a scientist who has helped to make the past thirty years the most extraordinary and significant in the history of physics.

Dr. Millikan's researches on the "cosmic ray" began in 1915. As early as 1903, British physicists, and somewhat later Swiss and German scientists made investigations indicating that penetrating ray—at first called "the penetrating radiation of the atmosphere"—came from outside the earth and were of cosmic origin. Dr. Millikan planned to test these conclusions by sending up electroscopes as close as possible to the top of the atmosphere. The war interrupted his activities and called him to service as Vice-Chairman of the National Research Council and as Chief of Science and Research of the Signal Corps. In 1923, Dr. Millikan resumed work on the proof of the existence of the mysterious "cosmic rays." Specially constructed instruments

2. The ideas embodied in this article were suggested by the book "Everyday Science Projects," by Edith Lillian Smith, Chapter XXIII. Directions for making the kites and gliders mentioned are to be found in this chapter.

were sent up under his direction at Kelly Field, Texas, to a height of about ten miles. The result of this experimentation showed one of two things:—either that the rays of cosmic origin, if they existed, were very much harder (i. e., more penetrating) than European observers had imagined, or that the indicated ionization was due to material existing in the atmos-

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phere itself. During the following summer Dr. Millikan and Dr. Russell Otis carried 300 pounds of lead and a tank of water to the top of Pike's Peak for experimentation, only to learn that very high altitudes were absolutely necessary in order to obtain crucial tests as to the existence or non-existence of these hypothetical rays.

From this earlier experimentation developed a definite plan of testing, namely that of sinking electroscopes to various distances in deep lakes situated at high altitudes, these lakes to be snow-fed to prevent radioactive combination by the seepage of water through the earth. Accordingly in 1925, Professor

Millikan conducted experiments, first at Muir Lake (altitude 11,800 feet), a beautiful, very deep, snow-fed lake just under the brow of Mount Whitney, the highest peak in the United States, and later at Lake Arrowhead, another very deep, snow-fed lake, in the San Bernardino Mountains, 300 miles farther south, with an elevation of 5,125 feet.

Let Dr. Millikan summarize his findings: "By the use of a formula of probable, though not of certain reliability, we find that our hardest observed rays have a frequency at least fifty times that of the hardest gamma ray, a thousand times that of the average X-ray, and about ten million times that of ordinary light. Our experiments further showed that these rays of cosmic origin are hardened as they go through the atmosphere, just as X-rays are hardened in going through lead, and thus we infer that we are working with a region of spectral frequencies about an octave in width and ten million times above the octave of optical frequencies to which our eyes respond."

This past summer Millikan made a pilgrimage to the Andes Mountains of South America, to check up further on his findings. The results of his latest research have not yet been made public officially, but newspaper interviews indicate that what Dr. Millikan found in the Andes, confirms the existence of the cosmic ray and the theory that it is constantly hitting the earth from every direction and is the most penetrating ray known. The cosmic ray, according to Dr. Millikan, appears to show that something is happening throughout the depths of space, quite independently of the sun or any central body.

Previous to the cosmic discoveries, Dr. Millikan's best known work was in connection with the so-called oil drop experiments undertaken to measure fundamental electrical quality. It was his work in isolating and measuring the electron and in making the first exact photoelectric determination of the light quant that won him the Nobel prize in physics in 1923. In the same year he won the Edison Medal, and the Hughes Medal of the Royal Society of London, for his determination of the electronic charge and other physical contents.

A physicist of the first rank, Dr. Millikan holds a rosy view for the future of scientific research in physics. "Today," he said in a lecture delivered during October, under the Terry foundation at New Haven, "we can still look out with a sense of wonder and reverence upon the fundamental elements of

the physical world as they have been revealed to us in the twentieth century. We know now that the childish mechanical conceptions of the nineteenth century are grotesquely inadequate. We have now no one consistent scheme of interpretation of physical phenomena and we have become wise enough to see and to admit that we have none. We have learned to work with new enthusiasm and new hope and new joy, because there is still so much that we do not understand; because we have actually succeeded in our lifetimes in finding more new relations in physics than had come to light in all preceding ages put together; and because the stream of discovery as yet, shows no sign of abatement."

A Modified Form of the True-False Test

BY HOWARD Y. MCCLUSKY and FRANCIS D. CURTIS,
University of Michigan.

Ever since its first appearance, about seven years ago, the True-False test has been a widely-used and popular measuring device. Recently, moreover, its popularity seems to be increasing with the teachers of science, particularly of general science, a fact which is indicated by the recent appearance of several standardized True-False tests in that subject.

While the True-False is doubtless a useful and valuable form of test, there has always been considerable objection to it because (1) it facilitates the "proclivity to borrow from one's neighbor,"[1] (2) it is unsatisfactory "as an instrument for diagnosing special individual difficulties,"[2] and (3) it permits more or less successful guessing of the correct response. As regards this third criticism, while Ruch states that "pure guessing (in the True-False) is comparatively rare with most individuals,"[3] some guessing, nevertheless, is generally admitted as a probability, and consequently the "guessing factor" constitutes probably the most serious objection to the True-False; for one cannot tell whether the correct response to any given

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1 F. B. Knight, "Data on the True-False Test as a Device for College Examinations," Journal of Educational Psychology, XIII (1922), 75-80.

2 H. M. Barthelmess, "Reply to a Criticism of Tests Requiring Alternative Response," Journal of Educational Research, VI (1922), 357-59.

3 Giles M. Ruch, "The Improvement of the Written Examination," (New York: Scott, Foresman & Co., 1925) pp. 116-17.

True-False statement is the result of accurate knowledge or clever analysis, or of lucky guessing.

The authors have recently completed a limited investigation with a modified form of the True-False, which seems in so far as the results may be indicative, to possess several marked advantages over the original form. The investigation was conducted with five calsses in science in the University (of Michigan) High School, one each in ninth and seventh-grade general science, two in eighth-grade general science, and one in tenth-grade biology. A test of fifty true-false items was prepared for each class; each test was divided into two halves, each half containing the same number of true statements, but having about twice as many false as true statements. The items in the respective halves were paired as accurately as could be done subjectively with respect to type and difficulty. For each class the entire set of statements was mimeographed as Sheet I, and an exact duplicate of the items on Sheet I was mimeographed as Sheet II, with the exception that the items in the second half of I became those of the first half of II. Thus numbers one to twenty-five on Sheet I became numbers twenty-six to fifty on Sheet II, and vice versa. Both Sheets I and II were administered to each class during a single class period.

The directions upon Sheet I were as follows:

Some of the following statements are true, and some are false. Put a letter "T" in the left margin opposite the statements you consider to be true as stated, and an "F" opposite those you consider false. Do not fail to mark all of the statements. In all cases when in doubt guess.

Examples: 1. T Carbon dioxide is more dense than air.
2. F Carbon dioxide is more dense than water.

The directions upon Sheet II were as follows:

Some of the following statements are true and some are false. Put a letter "T" in the left margin opposite the statements you consider to be true as stated, and correct the statements you consider to be false, by changing not more than two words in the original statement so as to make it true. Make all changes in the form of *substitutions*. No credit will be given for false statements which are corrected merely by the insertion of the word "Not." Do not change the subjects of any of the statements.

Examples: 1. T Carbon dioxide is more dense than air.
less
2. Carbon dioxide is more dense than water.

SOME TYPICAL ITEMS AND RESPONSES, SELECTED FROM THE VARIOUS SHEETS I, FOLLOW:

1. T An eclipse of the moon occurs only at full moon.
2. F An inflated tire weighs less than it would if it were not inflated.
3. F The plant seed contains the embryo and all the substances needed for its development except fat.
4. F The response which plants make to gravitation is called phototropism.
5. F A fireplace heats the room mostly by conduction.

Correct responses to these same items on the corresponding Sheets II follow:

1. T An Eclipse of the moon occurs only at full moon.

   more
2. An inflated tire weighs less than it would if it were not inflated.

   (If allowed to change three words, the pupil may correct this item thus:)

   A deflated
2. An inflated tire weighs less than it would if it were not

   deflated

   inflated.
3. The plant seed contains the embryo and all the sub-

   water

   stances needed for its development except fat.

   light
4. The response which plants make to gravitation is called photopism. (Or, since this item can be made correct by substitutions in two different ways:)
4. The response which plants make to gravitation is called

   geotropism

   phototropism. *radiation*
5. A fireplace heats the room mostly by conduction.

It will be noted that the sole difference in the two test sheets is that with Sheet I, the pupil is required only to decide whether the statements are true or false, and then to mark them T or F, as the case may be; but with Sheet II, he must not only decide whether the same statements are true or false, but he must analyze the false ones to detect what the false element or elements in them are, and then must substitute for the false words others which correct the inaccuracies in the original statements.

THE INVESTIGATION FURNISHED EVIDENCE IN SUPPORT OF THE FOLLOWING CONCLUSIONS:[4]

1. *The Modified Form takes more time to administer than the True-False.* For the five classes in science, the average difference in median time was 38.2 per cent. In marking the tests, it was found, moreover, that somewhat *more time is required to score the Modified Form than the True-False,* though, after a few papers have been scored, the extra time required for the Modified Form is very little. With respect to statements which admit of more than one correct answer, it is easily practicable to make a key which indicates the acceptable alternatives. Occasionally, as in the Completion Form of test, though less frequently in this Modified Form of True-False, an admissible answer is given which did not occur to the examiner in making the test; but these cases are relatively rare, and their noting does not require much additional time, nor do such sporadic cases appreciably affect the objectivity of the test.

It should be stated, also, that in so far as could be judged, it takes not longer to construct items for the Modified Form than it does to make *good* statements for the conventional True-False; and from the nature of the corrections required, the Modified Form is probably apt to contain fewer inconsequential items than the True-False. One, moreover, soon acquires the knack of constructing suitable test items for the Modified Form.

It may appear, on first thought, that the pupils themselves will not be able to score the Modified Form, but practice shows that they can score it satisfactorily. Slightly more time is required in scoring the Modified Form than is needed by them in correcting the True-False, but this added expenditure of time is amply justified through the added discussion occasioned by the effort to determine the proper answers. Further discussion gives the Modified Form a teaching value superior to that of the True-False.

2. *The Modified Form possesses a greater usefulness in homogeneous Grouping for drill upon certain units of work than does the True-False.* This fact is indicated by the consistently greater standard deviations of the Modified Form. *The Modified Form, moreover, is superior to the True-False*

4 For the statistical evidence supporting these various numbered statements, see the authors' complete report of this investigation in the Journal of Educational Research, XII (1926), 213-24.

for the diagnosis of individual and class difficulties and weaknesses. For example, occasionally a pupil changes a statement which is already correct in such a way that it is still correct, though with altered meaning; such a reaction is therefore welcomed as being indicative of confusion about that particular point in the pupil's mind, and as revealing a teaching opportunity which the True-False could not bring to light.

3. *The Modified Form is a better power test than the True-False.* A number of the more able pupils actually scored several points higher in the Modified Form than in the Old Form, because, as several stated, under the necessity for more careful analysis and reasoning in the former, they discovered meanings overlooked when taking the True-False. On the other hand, the weaker pupils, almost without exception, made higher scores in the True-False.

4. *The Modified Form is more reliable than the True-False.* The reliability of the former, computed from Brown's formula, was found to be .93, and of the latter, .82. The reliability of the Modified Form, moreover, compares favorably for tests in science with the reliability of the Recall and Multiple Response tests experimented upon by Ruch.[5] The reliability of Ruch's Recall and Five-Response tests, computed also from Brown's formula, were respectively .90 and .89.

5. *The Modified Form is more difficult for the pupils than the True-False.* The stronger pupils, however, like the Modified Form better. They enjoy the challenge of the puzzle element and the stimulus to wholesome competition offered by the Modified Form, which they think gives them a better chance to reveal what they really know. This Modified Form, moreover, since it demands a focus of attention upon content, eliminates whatever tendency there may be on the part of the more alert pupils to concentrate upon the mere mechanics and technique of wording of the statements.

6. *The Modified Form tends to eliminate whatever elements of guessing may be functioning in the True-False.* Lucky guessing seems hardly possible in a statement demanding the changing of one or two words. With the Modified Form, moreover, the "guessing factor" can be entirely eliminated by making all the statements false, and by so informing the pupils at the beginning of the test.

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5 Ruch, op. cit. p. 99.

Study of Aeronautics in our Universities

There are today five universities in the United States with personnel, laboratories and equipment sufficient for the complete training of aeronautical engineers in both undergraduate and graduate work. During the past year these five institutions had 96 students under instruction in regular aeronautical engineering curricula. These figures are taken from reports received from colleges and universities throughout the country in answer to a questionnaire distributed by the Daniel Guggenheim Fund for the Promotion of Aeronautics.

The reports received from the questionnaire indicated that 23 institutions in the country are giving some attention to aeronautical subjects, but the greater number of these have no particular equipment or staff to give serious attention to aeronautical engineering education. However, in addition to the five institutions equipped for complete aeronautical training, there are four others which have established either chairs or departments of aeronautics and which are offering elective subjects in aeronautics to engineering students.

The questionnaire was distributed to more than 500 institutions. A recapitulation of the answers received follows:

Number of institutions giving instruction of some kind in aeronautics	23
Number of institutions having school or department of aeronautical engineering or chair of aeronautics	9
Number having aeronautical laboratory or equipment to conduct aeronautical tests or research	14
Number offering graduate courses in aeronautical engineering	10
Number offering fellowships to graduate students in aeronautical engineering	7
Number offering a course in aeronautical engineering leading to a degree	5
Number providing elective subjects in aeronautical engineering to students taking regular engineering course	21
Number carrying on organized research in the field of aeronautics	8
Number of undergraduates taking regular aeronautical engineering curricula leading to a degree	96
Number of undergraduates taking regular engineering curricula electing certain subjects in aeronautics	163
Number of graduate students taking courses in aeronautical engineering	26

Laying the World's Fastest Ocean Cable*

CHARLES W. BARRELL TELLS OF FILMING THE LANDING OF THE PERMALLOY CABLE FROM BAY ROBERTS, NEWFOUNDLAND, TO PENZANCE, ENGLAND

The nearest thing to a midway station between America and England, the ancient island colony of Newfoundland is one of those countries which the many pass by and only the few visit.

This is not due to any inherent lack of picturesque quality in the place of its people. As a matter of fact, the rugged scenery, vast unsettled areas, now serving only as natural forest and game reserves, and the hardy and independent character of the natives, should appeal strongly to the visiting stranger from almost any clime.

Newfoundland, indeed, seems blessed with every qualification to make it the summer resort *par excellence*—except one. Location. It fronts on the Graveyard of the Atlantic, at a point where the humid Gulf Stream and that liquid river of ice which flows out of the Arctic Ocean parallel each other.

To reach England's oldest colony one must, therefore, be prepared to spend an indefinite time, varying from hours to days, on a stretch of uneasy, fog-infested salt water, haunted for months each year by ghostly and treacherous mountains of float-ice—one of the most dangerous and disquieting sectors to be found throughout the seven seas.

By virtue of its geographical position, however, Newfoundland has just naturally developed into the most important of all junction-points for Atlantic submarine telegraph traffic. Since the year 1858, when Cyrus Field and his associates connected the Old World with the New by wire, up to the present day, many important epochs in the history of ocean telegraphy have been celebrated on its rocky shores.

Through the courtesy of the Western Union Company, I was given the opportunity to visit Newfoundland during the present summer. Walter Pritchard, the youthful cineomatographic veteran, accompanied me. The purpose of our expedition was to secure a motion picture record of the landing of the new per-

* Extracts from an article in "Western Electric News," by courtesy of the Western Electric Company.

malloy, high-speed cable, designed by Western Electric engineers and recently laid between Bay Roberts, Newfoundland, and Penzance, England.

Pritchard and I traveled by rail from New York to Halifax, Nova Scotia, where we signed on as members of the crew of Western Union's crack new cable repair ship, *Cyrus Field*. On the *Cyrus Field* we journeyed east, north-east over the six hundred-odd sea miles which separate Halifax from Bay Roberts.

The working equipment which we took with us included three trunks, containing arc lamps for the photographing of interiors a standard model motion -picture camera, and a small, motor-driven camera, built to take short-length movie scenes without a tripod. An Ica reflex camera for "still" pictures with a shutter capable of working at a maximum speed of 1/1300 of a second, completed the photographic battery.

Fifteen nights and almost as many days we spent on the good ship *Cyrus Field*. And during that time we experienced varying degrees of equilibrium, equipoise, or whatever the study of the human body's position in relation to the fixed center of the earth may be. Also, we sampled a variety of weather conditions too wide to bear enumeration. During most of the run out and back the ship rocked her way cautiously through greasy-gray seas in a dripping blanket of fog to the ear-shattering screech of the siren. But these fleeting discomfitures notwithstanding, it would be a gross breach of veracity not to say that the trip was stimulating both to body and mind.

On the morning of the third day out from Halifax we came to anchor in the picturesque harbor of Bay Roberts.

Codfish and cables are the mainstays of this interesting settlement. Some three hundred houses, fifteen or twenty stores and eight churches cluster about the sharply-indented waterfront.

On the north shore the Western Union Company has built a neat village for those of its employees who must make the place their permanent residence.

A substantial brick building, a few yards back from the beach, houses the cable station. Underseas telegraph lines from both England and America enter the building, and the volume of cable traffic relayed here is so heavy that operating shifts are kept on duty day and night.

Hills of solid rock rise behind the village. Looking on these bald, arid knobs, the American visitor instinctively recalls certain parts of Colorado and Utah—until the sights and smells nearer at hand blot out the illusion with a flood of ultra-marine atmosphere.

As it soon became apparent that there were many details in connection with the proper landing of the new cable to be threshed out and arranged for by Captain Bloomer and Superintendent Jones, of the Bay Roberts station, we decided to make the most of our shore leave by taking an historical detour some forty-odd miles across country to Heart's Content, on Trinity Bay.

I would be loath to advise a motor trip from Bay Roberts to Heart's Content to any one subject to neurasthenia. The highway, sketchily laid out to begin with, wanders here and there at illogical angles, while pebbles, varying in size from the egg of a humming-bird to that of an ostrich, test tires, springs and seat cushions to full capacity.

But in physical and human interest, Heart's Content proved worthy of the jolts we were obliged to absorb in reaching it. For this quaint fishing village, sprawling on the edge of an inlet of Trinity Bay, has a secure place in the history of the submarine telegraph.

It is now sixty years since the *Great Eastern,* first of all the modern ocean-going giants, steamed into Trinity Bay, trailing behind her on the ocean bottom a continuous line of insulated copper wire, the European end of which was securely anchored on the west coast of Ireland.

On July 27th, 1866, the *Great Eastern's* tender, the *Bloodhound,* sent the cable ashore at Heart's Content. This was probably the most exciting day that the drowsy little settlement

ever had or ever will experience, until the end of time. Through the good offices of C. H. Transfield, local justice of peace and superintendent of the Heart's Content cable station for the past thirty-six years, we were enabled to meet and photograph one John Warren, an eighty-year-old veteran of that memorable occasion, who as a youth helped drag the first successful Atlantic telegraph cable to land in the western hemisphere. Mr. Warren said that practically the whole population of Newfoundland, as well as hundreds of strangers, were present in Heart's Content that day. In their eagerness to be the first to touch the new cable, crowds of men rushed out in the water up to their necks.

The broken shore-end of the historic cable of 1866, the first successful ocean telegraph laid by the "Great Eastern" just sixty years ago. This picture was taken at Heart's Content, Newfoundland, where the great event took place. C. H. Cranfield, appearing in the picture, has been Superintendent of the Western Union Cable Station at Heart's Content for 36 years, and his father was a member of the crew of the "Great Eastern."

We also secured pictures of the tiny cottage, still in excellent repair, in which the first cable to successfully span the Atlantic was opened to telegraphic traffic.

Then Mr. Tranfield led the way to the rocky beach below the village where we uncovered the broken shore-end of the original cable. It was most interesting to discover that the gutta-percha insulation on this historic relic was still to all appearances as snug and resilient as the day it was moulded on its seven-stranded conductor core, more than half a century ago.

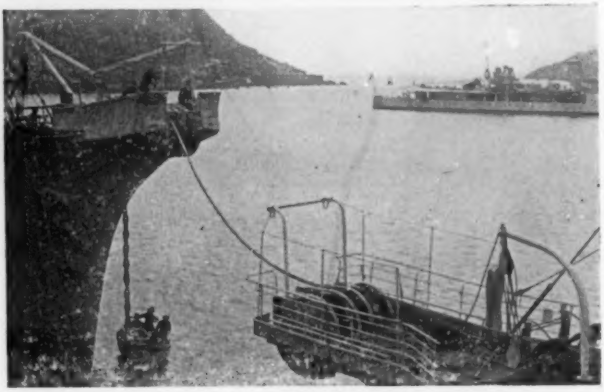
Back in Bay Roberts we found that Captain Bloomer and his associates had completed arrangements for the landing of the new cable. So next day we steamed off for St. John's, the metropolis of Newfoundland, to await the arrival of the *Colonia* from England with its 2,000-mile cargo of permalloy cable, fresh from the works of the Telegraph Construction and Maintenance Company at Greenwich, near London.

St. John's is one of the world's unique ports. It is hidden away behind ramparts of rock, rising sheer from sea level to over five hundred feet above the rolling combers. A narrow passage gives entrance to the harbor, which is a deep basin, scooped out as neatly as though it had been made to order. The city, with a population of 35,000, is built from the water's edge back along the steep ledges which rim the harbor 'round. Several handsome stone buildings, including a new $2,000,000 hotel, catch the glance as one looks toward the city proper. But the northern shore holds out fascinating prospects to the pictorial explorer with its terraced cottages running up from high-water, almost to the top of the cliff. The strange-looking scaffolds, covered with spruce boughs, which stand in front of the weather-beaten houses are called "flakes" and are utilized in drying fish. The weird setting and soaring clutter of unsubstantial-looking structures gives an Oriental suggestion to the scene. Away overhead the ruins of the old fort on Signal Hill stands the Cabot Tower, built of solid blocks of granite to withstand the pressure of the roaring north-east gales. This building was the center of the world's interest in 1901, when Marconi used it as his headquarters in sending the first wireless message to Europe.

Through the early morning mists a day or two later, the *Colonia* slipped quietly into the harbor with its $3,500,000

cargo neatly coiled away below decks. Felicitations and congratulations were exchanged between the two ships, after which the transferring of the Newfoundland shore section of the cable from the *Colonia* to the *Cyrus Field* took place. This shore section is said to be the largest and heaviest piece of submarine cable that has ever been fabricated. It contains three separately insulated conductor cores, has a total diameter of 3¼ inches, and weighs 36 tons per mile. It is built to withstand electrical interferences from land sources and other cables which may lie near it. And it should also hold its own in the eternal conflict with a restless sea, jagged rocks and grinding ice-floes.

On the way back to Bay Roberts we were favored with weather of classic Italian mildness and brilliancy. In fact, it was so suspiciously mild and brilliant that no one was particularly surprised, early Monday morning, to find the thermometer had dropped more than twenty degrees in the teeth of a raw Easterly rainstorm when we turned out to see the cable waiting on the beach, every last man covered from crown to heels in oilskins. It was a picturesque sight, but the rain, the early hour and the lack of sunlight made it photographically depressing. Pritchard and I had chartered a motor fishing



Here the cable is being transferred from the "Colonia," which brought the cable over from England, to the "Cyrus Field," which handled the landing operations at Bay Roberts.

dory the day before, which was awaiting us by the overside gangway. Grimly shouldering our cameras and clutching the actinic flares which we had brought along in obedience to some clairvoyant premonition, we floundered aboard our dory and made for the prow of the ship, over which the cable had already started to wriggle in long serpentine loops. In a small boat below two members of the *Field's* crew, stripped for action and dripping wet, were working like mad to keep up with their job of attaching air-tight barrels to the slippery cable at regular intervals. These barrels floated the cable ashore. Without them, it would probably have required 150 horses instead of men, to drag the snake-like monster in.

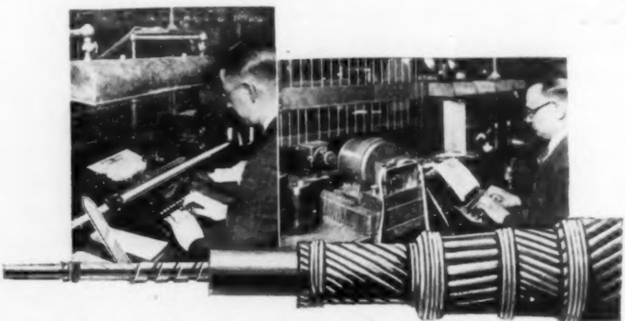
Typical Newfoundland weather, including a raw, cold drizzle, greeted the new permalloy, high-speed cable when it came ashore from the "Cyrus Field" at Bay Roberts. Air-tight barrels float the wriggling, serpent-like cable in to the beach.

The cable got ashore safely, and when I saw my late commander, Captain Bloomer, in New York, recently, he told me that the new cable had outstripped expectations by displaying a speed capacity of 2,500 letters a minute before the sending and receiving apparatus had been fully tested.

2500 Letters Per Minute Over World's Fastest Cable *

EFFIENCY OF LATEST NEW YORK-LONDON CABLE INCREASED EIGHT-FOLD BY THE "MAGIC METAL," PERMALLOY.

In one great forward step, the Western Union Telegraph Company has speeded up deep-sea cable transmission to 2,500 letters a minute by the aid of Permalloy, the "Magic Metal." Wrapped around the entire 3,800 mile length of the copper conductor of their new across-the-Atlantic cable, a single thin strip of Permalloy, only 6-1000ths of an inch in thickness, gives an efficiency eight times greater than any other similar link connecting New York and London.



The world's fastest cable, with its wrapping of Permalloy, made radical improvements necessary in the machines for sending and receiving messages.

Speeding up the new cable by "loading" it with Permalloy was made possible by the engineers of the Western Electric Company, who perfected this alloy of approximately 80% nickel and 20% iron to a point where, under conditions met with in deep sea cable transmission, its premeability was many times greater than that of any other known substance.

The speed attained is possible due to the fact that "loading" the cable increases the electrical inductance of the conductor, thus applying one of the scientific principles which made long distance telephony possible. How Permalloy "loading" operates to increase the message carrying capacity of a copper wire calls for a brief explanation of the way in which ocean cables are operated.

* From *Inco*, by courtesy of International Nickel Co.

Early in submarine cable history, the land-telegraphy method of differentiating dots and dashes was found too slow, and impractical. Instead of these dots and dashes, differing from each other in length of time, and read by the operator's ear, cable signals are produced by currents of opposite polarity which actuate delicate devices read by the eye. Though of exactly the same duration, an impulse caused by a brief connection between the cable and the positive pole of a battery causes a deflection in one direction of a galvanometer thousands of miles away, indicating a dot; while an equal negative impulse will cause a deflection in the opposite direction signifying a dash. The cable's "power plant" consists only of one 50 volt battery, sending a current of one-tenth of an ampere for each impulse. Heavier voltages tend to destroy the insulation, rendering the cable useless after a short period of use. The first cable laid at an expense of one and a half million dollars was thus destroyed.

However, actual practice of this operation explained above, involves many difficulties. Cable signals, or impulses, drag long "tails" behind them, upon which succeeding signals tread. In high speed transmission over long distances, the impulses follow each other so rapidly that they overtake the "tails" of those preceding and mingle into confused, unintelligible signals. As transmitting speed was increased such confusion became too great for any expert to decipher the messages received.

Electrically speaking, it is not accurate to say that "loading" a cable with Permalloy actually increases the speed of the impulse. They are, in fact, slightly retarded, though it takes but a fraction of a second for each individual signal or wave to pass along the cable from New York to London. What is actually accomplished by a "loaded" cable wrapped with this new nickel-iron-alloy is that during transmission from one end of the cable to the other, signals may follow one another at a greatly reduced interval of time without overlapping and consequent confusion; so that where heretofore the fastest cable was capable of a speed little more than 300 letters a minute, with most of those in operation limited to 150, the discovery of permalloy permits the sending of 2,500 letters each minute, with as many as eight automatic devices transmitting simultaneously.

The economic importance of Permalloy is instantly obvious, since the traffic capacity of the cable is multiplied several hun-

dred per cent. at an investment cost only moderately greater than the previously standard type of cable. Providing the first great improvement in deep-sea cables since Cyrus Field connected the two continents in 1858, it is no wonder that Permalloy is termed the "Magic Metal."

In the race between radio and cable for supremacy in Trans-Atlantic communication, Permalloy puts the cable several laps ahead. The popular idea that the success of international radio spells the eventual doom of the cable is hardly borne out when cable companies continue to spend the several millions which a new cable costs, with full knowledge of radio's capacity and the lines of its probable future development.

Chemical Warfare is Here to Stay

By J. Merritt Matthews

I have been much interested in the many arguments pro and con relative to the future of chemical warfare which means, of course, the use of various gases and chemicals as substitutes for high explosives. The various remarks, made at Williamstown and other places by American chemists in support of chemical warfare as opposed to the popular propaganda against it on the basis of it being abhorrent and inhuman, are all very interesting and very truthful, but unfortunately they are entirely beside the real point at issue.

There are many apparent reasons given out for popular consumption as to why chemical warfare should be prevented or restricted by the adoption of international agreements, but the real reason is that the powers that be have come to realize that this method of warfare is far more effective than any other system of fighting yet devised. It is not because it is more inhuman but because it can more readily and completely overcome the enemy. And then underlying it all is the deeper reason that it represents a novel departure from the traditional methods of fighting.

Most of the statesmen and military authorities of both France and England are strongly opposed to chemical warfare, simply because its application in the Great War has amply demonstrated its tremendous efficiency in overcoming the enemy. If chemical warfare were to be developed to the point towards

which it seems to be headed, the preponderance of military power and in consequence, national prestige would no longer be confined to those nations capable of putting tremendous armies in the field, but would be open to any nation that was clever enough to manufacture and use the various chemical agencies that have so far been devised or which may be further developed by chemical research and enterprise. The whole system of warfare would have to be changed; there would be new standards of military efficiency to be adopted, and the vision of these is for the most part far beyond the mental grasp of the ordinary statesman or military leader.

As to the banal arguments that the methods of chemical warfare are inhuman and cruel, these have been so clearly and so definitely refuted by actual statistics and the presentation of the facts, that it would hardly seem worth while to dwell at any length on this phase of the case. When the police authorities of a town are threatened by a riot and an overpowering mob, it is not the custom, nowadays, to charge them with cavalry and bludgeons or to kill and maim then with shot and explosive shells. Our tender mercies no longer permit such crulety; instead the authorities are more likely to turn the fire hose on the mob, or in further extremity to drench the recalcitrants with tear-gas or ammonia or other of the "dreadful" war gases, depending on the seriousness and exigencies of the case. We all know that the latter methods have nothing especially inhuman in them, but they are far more effective in dispelling and quieting the mob than shooting would be. The latter method so much favored by military authorities kills and maims a few individuals, but, instead of quelling the spirit and will of the mob, it only serves as a rule to increase its fury. A good dose of "gas" however, soon takes the spirit and the will to fight out of the most unruly mob, and, while not permanently disabling anybody, is highly efficient in putting the entire body completely hors de combat.

In a recent article in *Le Matin,* one of the leading French military authorities discusses chemical warfare, and takes the occasion to point out that if Germany were allowed to maintain her efficiency in chemical manufacture, Paris, and therefore France, would always be in danger of being overwhelmed in the event of a new major conflict between the two countries. Germany could drench Paris with war gases, using as a method

of attack say 30 or 40 flocks of 100 airplanes each, carrying in this manner a vast number of gas bombs over the city. According to the imagination of the French general, the city of Paris would be put out of the running in short order. What would most likely happen, in reality, would be that most of the inhabitants would rapidly flee to less infected areas. There would no doubt be more or less casualties among those who for one reason or another could not get away, but would these casualties bear any comparison to those that would occur were Paris subjected to a bombardment with high explosive shells in a like degree of intensity, and how about the property damage that would occur in the latter case?

If one studies the history of nations at all, one cannot but be impressed with the remarkable stolidity of War Departments. In the old days when warfare by means of shot and shell was first introduced, there was a loud outcry against the use of such inhuman and dishonorable methods. Personally we cannot see why it was thought to be more inhuman to kill and maim men with bullets and shells than to cut off their heads with a sword or dash in their brains with a mace. But people were accustomed to being killed and wounded by one method and they viewed with horror any innovation. The military authorities, however, were dead set against the new-fangled methods, not because they were more inhuman, but because they were so much more effective. A small army provided with guns and pistols and sufficient ammunition could quickly overcome a large army of fighting only with the old-time weapons; in fact the whole system of military manoeuvers would have to be revised.

If there is anything more immovable and less prone to innovation than a War Department it has yet to be discovered. The military man no doubt owes this lack of plasticity to his rigid training in discipline and reliance on authority. Anything that is not in the military manuals cannot possibly be true or of any value. The old physicists who formulated the laws of motion and studied the resistance to change as manifested by the heavenly and earthly bodies, never studied the inertia of a War Department towards any change of method. Napoleon conquered practically the most of Europe, not because he had a greater army at his disposal or because his men were braver and more courageous than his opponents, but simply because he cast

all tradition and military precedents to the winds and introduced off-hand innovations in method dictated solely by the clear-sighted vision of his own genius. He was denounced as dishonorable and inhuman; it was claimed that he did not play the game according to the rules, but just the same he won the battles. He set his mind on getting results and on getting them in the most thoroughly effective manner.

The same thing is just as true now as it was then. Any student of military history will recognize right away the utter futility of trying to head off the use and development of the so-called "chemical" warfare. If it is more effective in its purpose it will certainly be employed in the next great war, whenever that may take place. The passing of laws against its use or the formation of international rules on the subject will not have the slightest effect when the actual struggle comes. It is impossible to legislate knowledge out of the minds of men. All nations of any standing at the present time are perfectly familiar with the methods of making and of using the various military gases; chemists are not confined to any one nation, and chemical research and investigation are continually going on, and it is difficult to understand how international agreements fashioned at Geneva or elsewhere could have much effect in limiting them. As to the manufacture of these materials any modern chemist or engineer with common sense could readily understand that it would be only a matter of a few weeks under the pressure of military necessity to construct plants and get going in the actual manufacture of almost any of these chemical products. The limitation of chemical factories in peace-time would have little effect on the potential production of these materials in time of actual war.

These bizarre notions about forbidding or restricting "chemical" warfare by international agreements through the League of Nations or through any other international medium are doomed to failure in case occasion ever demands their actual application. When we have a prize-fight or boxing-match for sport we carry it out under definite rules and procedure, but when a lot of ruffians get into a fight over some stolen treasure, they don't stand on ceremony; it becomes a knock-down and drag-out affair, and any means that comes to hand for either defensive or offensive fighting will be adopted. When two

nations become engaged in a major conflict of actual warfare; when both are valorously fighting for their self-preservation, they also cease to stand on ceremony. All rules are abrogated, and any means of overcoming the enemy that may come to hand is utilized. While it is true, perhaps to some limited extent, that the dictates of a common humanity prescribe as dishonorable certain practices, especially towards non-combatants, we fail to see how these can be applied to the general methods of "chemical" warfare.

No, the writing on the wall is plain and easily read; chemical warfare has demonstrated its effectiveness in the most complete manner; the charges against it of inhumanity are simply for propaganda gotten up by those who are silly enough to think that they can in some measure restrict it by laws. Why not call attention to the far greater inhumanity of explosive shells and machine gun fire? These are also chemical to a great extent, perhaps at least to the same extent as these war gases, so why segregate the latter as "chemical" and set the former apart as something proper and allowable? Picric acid and TNT are just as much "chemicals" as charges for explosive shells as mustard gas or other so-called "chemical warfare" materials.

—*Ind. and Eng. Chemistry.*

May Have Wind-Power Plants for Farm Electricity

Wind-driven electrical generators have not come into general use for rural homes because of the feeling that wind is too capricious a power to be depended upon. To meet a growing demand for an economical and efficient plant of this type, scientists of the Weather Bureau and the Nebraska State Agricultural College have made a study of wind velocity at Lincoln, Nebraska, over a ten-year period, to determine, chiefly, for what percentage of the time the wind is too light to operate such a plant.

A minimum wind velocity of ten miles an hour is necessary to charge batteries, it has been found. It is not necessary, however, to charge batteries continuously, or every day. So the wind need not blow at the rate of ten miles per hour throughout the day or on successive days. Under average conditions five hours' charging every two or three days is sufficient to keep the batteries in good condition.

Periods of from three to five consecutive days without sufficient wind to charge batteries were not frequent. They occurred oftener in late summer and early winter than in spring. Longer periods of low wind movement averaged less than one in a year, occurring in any season except the spring. Since the amount of electricity used on farms depends mainly upon the amount used for lighting purposes, more electricity is consumed during the months when the nights are longer. The batteries then require more frequent charging. It is interesting to find that in the darker months, when the wind power is most needed, the percentage of hours when it blows ten miles or more per hour is more than enough to charge the batteries sufficiently. Further investigation is needed in this field, but the day seems not far distant when hundreds of rural homes will have wind-power plants for generating electricity.

The New Books

Nature Guiding—William G. Vinal—551 pages—Illustrated—Comstock Publishing Company.

These chapters, written from the rich experience of Dr. Vinal, will inspire the readers with a love for the out-of-door life as the author has inspired hundreds of campers and students, who have been associated with him in their work and play. The book is full of suggestions and helps for teachers of nature study and camp councillors. Dr. Vinal's account of his experiences as a nature guide in the Yosemite, are intensely interesting.

New Civic Biology—George W. Hunter—448 pages—Illustrated—$1.68—American Book Company.

This book was written for use as a tenth year science course and assumes a basis of Elementary or General Science. It treats living things in relation to their environment and to each other; life process in living things and green plants as living organisms; general relations between plants and animals; animals as living organisms; responses in plants and animals; reproduction and classification; man's control of his environment in relation to health; man's control of his environment in relation to wealth; man's control of his environment for the improvement of plants and animals. The application of modern biology in the students' daily life is here presented in a very interesting and effective way. Each chapter opens with a series of problems which serve as a key to the text. They are suggestive to the teacher and stimulating to the student. Each chapter ends with a set of problem-questions and useful references. The book contains a helpful glossary.

Wild Birds in City Parks—H. E. & A. H. Walter—111 pages—price $1.50—The Macmillan Company.

This is a revised edition and gives valuable help in the identification of 203 birds commonly found in Northern and Northeastern United States and Canada. It contains hints, key, tables, and migration charts; all of which are of value in helping the amateur in the identification of birds.

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General Social Science—Ross L. Finney—459 pages—Illustrated—The Macmillan Company.

This text presents the principles by which the facts of social life can be interpreted. A list of supplementary reading makes the course elastic as to quantity. A list of problems and projects in each chapter relate the work to practical life around the student.

The Relation of Nature to Man in South America—J. F. & A. H. Chamberlain—203 pages—81 Illustrations—The Macmillan Company.

This is a revised edition and is enriched by an entirely new set of illustrations. The material is thoroughly up-to-date and will make valuable supplementary reading for the Elementary Geography work.

The Book of Knowledge Science Series—Edited by Ellis C. Persing, The Grolier Society, 2 West 45th St., New York City.

A series of science leaflets is being prepared for the busy elementary school teacher. Each leaflet has eight pages and covers one unit of study in Elementary Science. On the first page is a list of questions and in many cases, page references for finding the answer. The remaining pages are reprints of subject matter taken from the Book of Knowledge. Five leaflets have already been published, namely; The Immensity of the Universe; The Wonderful Amphibians; Bats and Their Friends; The Pigeons and the Doves; The Sponge and What It is. These will surely be very helpful to grade teachers. They are supplied to teachers free, by the Grolier Society.

A New Experimental Science—J. G. Frewin—92 pages—44 Illustrations—Price 50 cents—Oxford University Press, American Branch, New York City.

This is an experimental book, having altogether 73 experiments in three groups: (1) Elementary physics, mass weight, density, solution, hot and cold water expansion and the thermometer; (2) Elementary chemistry: Air combustion, oxygen, nitrogen, carbon dioxide; (3) Physics of air: Pressure, spring of air, vacuum, barometer. The experiments are simple and appealing to elementary students.

Social Arithmetic Book 3—Frank M. McMurry and C. B. Benson—338 pages—72 Illustrations—The Macmillan Company.

This is a most fascinating presentation of practical arithmetic. It deals first, with the child's own problems and leads on to those social problems he is bound to meet when he is older.

General Physics for the Laboratory—Taylor, Watson and Howe—247 pages—145 Illustrations—Ginn and Company.

College instructors will welcome this laboratory book because the essential text background for each experiment is given just when the student needs it. Also the equipment required for the experiments is all standard, and so easily obtainable. Photographs of apparatus set up, replace the usual teachers' description of how to assemble the laboratory apparatus. There is an appendix of useful tables and logs.

Booklet Just Published by the Rocky Mountain Teachers' Agency, 410 U. S. National Bank Building, Denver, Colorado. "How to Apply For a School and Secure Promotion with Laws of Certification of Teachers of the Western States, etc., etc." This booklet is sent free to members. It will be sent to non-members for 50 cents in stamps.

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Elements of Agriculture—G. F. Warren—549 pages—269 illustrations—The Macmillan Company.

This revised edition has new material which brings the book up to date in the matter of present-day Elementary Agriculture. It treats of plants and animals and their improvement; of plant food and the soil; of different kinds of crops and how to care for them; of cattle and feed; of farm implements, farm management and the home community. There are several valuable score cards. It is a book which will be much appreciated in the high schools.

New Physical Geography—Tarr and Engeln—689 pages—543 Illustrations—The Macmillan Company.

This is intended for high school study. It contains all the serviceable material of the original text, but has added material which the progress of science has shown to be necessary. Pictures, diagrams, and maps are used profusely and each one has educational significance. The book emphasizes the human interest side of Physical Geography. The large pages admit the use of large pictures which are particularly pleasing.

Sex Freedom and Social Control—Charles M. Margold—143 pages—Price $2.00—The University of Chicago Press.

The purpose of this book is, in the author's words: "To challenge what appears to be the postulate of some authoritative and scientific writers, who are urging radical changes in our moral ideas and practices, regarding sexual relations." The four chapters treat these subjects; the justification offered for some radical sex practice; radical practices cannot be justified by merely biological data; the invariable presence of social control in man's sexual conduct; the entrenched reality of group sex standards.

The Dentist's Assistant—Emma J. McCaw—119 pages—22 illustrations—Price $1.50—C. V. Mosley Co., St. Louis.

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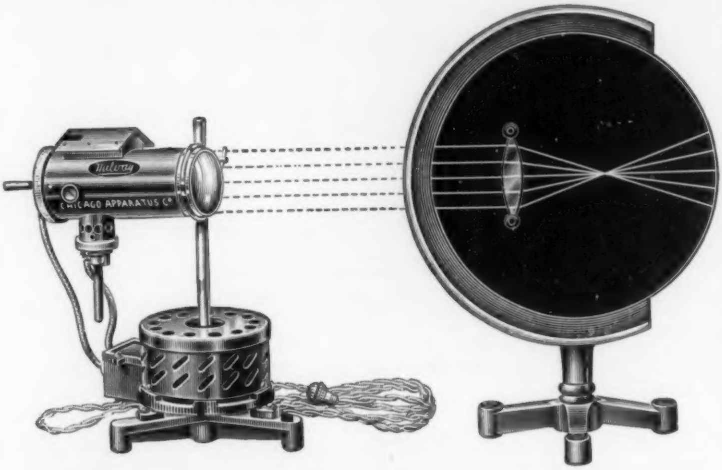

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ASTRONOMY

What lies beyond the stars. Lit. Dig., 90:12:25, Sept. 18, 1926.

Eclipsing stars. Sci. Mo., p. 256. Sept., 1926.

The origin of the earth. Sci. and Inv., 14:18, May, 1926.

ASTROLOGY

The astrology humbug. Sci. and Inv., 14:487, Oct. 1926.

AVIATION

Our civil aviation now leading the world. Lit. Dig., 91:7:23, Nov. 13, 1926.

How airplanes turn and fly. Pop. Sci. Mo., 109:2:35, Aug. 1926.

CATHODE TUBE

New cathode tube may replace radium. Lit. Dig., 91:5:22, Oct. 30, 1926.

The production of high voltage outside of the generating tube. Jo. Fr. Inst., 202:693, Dec. 1926.

CITY PLANNING

Regional planning makes suburban federations imperative. Am. City, 34:257, Mar., 1926.

What really is city planning? Am. City, 34:469, May, 1926.

COMMUNICATION

The world's first alphabet. Lit. Dig., 90:11:21, Sept. 11, 1926.

When you beckon with your finger. Pop. Sci. Mo., 109:4:14, Oct. 1926.

The magic lure of cyphers. Pop. Mech., p. 564, Oct., 1926.

COOLIDGE-RAY

A new tool for the research scientist. Sci. Am., p. 420, Dec. 1926.

EARTH

How old is the earth? Sci. Mo., p. 260, Sept. 1926.

FLOWERS

Dahlias on the Pacific coast. Gar. and Home Builder, 44:302, Dec. 1926.

Beauty doctors of the gladiolus. Gar. and Home Builder, 44:214, Nov. 1926.

Color harmony with tulips. Gar. and Home Builder, 44:225, Nov. 1926.

FUELS

*Future trend in automotive fuels. Ind. and Eng. Chem., 18:1009, Oct. 1926.

FRANKLIN

America's first great experimenter. (The Franklin stove.) Pop. Sci. Mo., 109:4:22, Oct. 1926.

(Electrical marvels.) Pop. Sci. Mo., 109:5:26, Nov. 1926.

GARBAGE

How Washington's garbage pays dividends. Sci. Am., p. 439, Dec. 1926.

GARDENS

A semi-tropical garden at New Orleans. Gar. and Home Builder, 44:231, Nov. 1926.

GLACIERS

Little known ice ages of great antiquity. Sci. Am., p. 272, Oct. 1926.

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Bringing children up to normal weight. Hygeia, 4:569, Oct. 1926.
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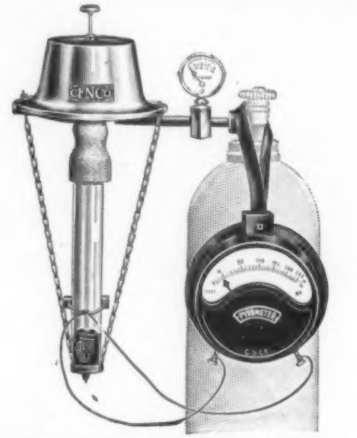
House heating. Pop. Sci. Mo., 109:6:31, Dec. 1926.
HELIUM
Solidification of helium. Sci. and Inv., 14:593, Nov. 1926.
HOME
Home lighting. Pop. Sci. Mo., 110:1:36, Jan. 1926.
HONEY
U. S. trade in honey and beeswax. Com'l Amer., 23:4:27, Oct. 1926.
LIGHT
Strange new marvels of light. Pop. Sci. Mo., 109:5:35, Nov. 1926.
LIGHTING
Asymetric street lighting. Am. City, 34:484, May, 1926.
LIGHTNING
Sixteen million thunder storms. Lit. Dig., 91:2:25, Oct. 9, 1926.
MAN
Fossil bones of early man. Sci. Am., p. 348, Nov. 1926.
MILK
A campaign for clean and safe milk. Am. City, 35:493, Oct. 1926.
MINING DISASTER
A cave-in. Pop. Sci. Mo., 109:6:9, Dec. 1926.
MOTION PICTURES
The place of motion pictures in modern life. Photo-Era Mag., 57:175, Oct. 1926.
Motion in motion pictures. Photo-Era Mag., 57:193, Oct. 1926.
PASTEUR INSTITUTE
Chemical research for the Pasteur Institute. Jo. Chem. Ed., 3:1217, Nov. 1926.
PETROLEUM
*The cracking of petroleum. Jo. Fr. Inst., 202:567-588, Nov. 1926.
The future of the chemical of petroleum. Jo. Ind. and Eng., 18:1019, Oct. 1926.
The rapidly diminishing oil supply. Com'l Am., 23:4:17, Oct. 1926.
PHOTOGRAPHY
Photography and its twelve immortals. Photo-Era Mag., 57:251, Nov. 1926.
PHYSIOLOGY
Our other brain. Lit. Dig., 91:1:23, Oct. 2, 1926.
PICTURES
What makes a picture artistic? Photo-Era Mag., 57:289, Dec. 1926.
RADIATORS
How cast iron radiators are made. Sci. and Inv., 14:784, Jan. 1927.
RADIO
A perfect static shield. Radio News, p. 337, Oct. 1926.
An auto-transformer receiver. Radio News, p. 353, Oct. 1926.
Our radio of tomorrow. Pop. Mech., p. 648, Oct. 1926.
Loud speakers and their characteristics. Radio News, 8:642, Dec. 1926.
RELATIVITY
*Present status of theory of relativity. Sci. Mo., p. 65. July, 1926.
RUBBER
Plantation rubber. Sci. Mo., p. 268-278, Sept. 1926.



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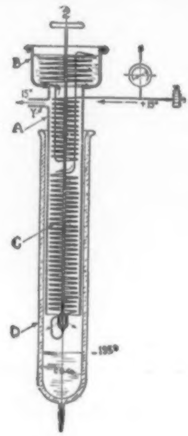

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Sanitation in the farm home. Hygeia, 4:615-617, Nov. 1926.

SEWAGE
World's largest sewer disposal problem. Hygeia, p. 284, Oct. 1926.

SCIENCE
The birth of modern science. Sci. Mo., 23:138-151, Aug. 1926.

*SCIENCE EDUCATION: PEDAGOGY
A method of increasing interest and of providing for individual differences in the High School science laboratory. Sch. Rev., 34:782, Dec. 1926.
A critical study of the content of High School physiology with respect to its social value. Sch. Rev., 34:688, Nov. 1926.
Qualifications of a chemistry teacher. Jo. Chem. Ed., 3:1277, Nov. 1926.
Laboratory reports in beginning chemistry. Jo. Chem. Ed., 3:1313, Nov. 1926.

SOUND
Recent development in the recording and reproduction of sound. Jo. Fr. Inst., 202:413-448, Oct. 1926.

VITAMINS
A square meal. Hygeia, 4:611-614, Nov. 1926.
The vitamins. Jo. Chem. Ed., 3:240, Nov. 1926.

WATER POWER
Harnessing 30,000,000 horse power. Pop. Sci. Mo., 109:6:22, Dec. 1926.

WATER SUPPLY
Scituate water supply project for Providence, R. I. Am. City, 35:309, Sept. 1926.

WEATHER
Will 1927 be a year without a summer? Pop. Sci. Mo., 109:5:23, Nov. 1926.

THINGS TO MAKE

MODEL FORCE PUMP. Sci. and Inv., page 613, Nov. 1926.

SOLID ALCOHOL. Sci. and Inv., page 612, Nov. 1926.

MINIATURE VOLCANO. Sci. and Inv., page 613, Nov. 1926.

ELECTRIC CIRCUIT BREAKER. Sci. and Inv., page 614, Nov. 1926.

ELECTRIC MOTOR FROM ELECTRIC BELL. Sci. and Inv., page 615, Nov. 1926.

MANOMETER. Sci. and Inv., page 45, May, 1926.

HIGH PITCH BUZZER. Sci. and Inv., page 48, May, 1926.

A SENSITIVE BRIDGE GALVANOMETER. Sci. and Inv., page 711, Dec. 1926.

Magazine List

American City. 443 Fourth Ave., New York City. Monthly. $4.00 a year, 50c a copy. The science problems of city and rural communities are treated in numerous articles, well illustrated. A valuable student and teacher reference.

The American Food Journal. 468 Fourth Ave., New York City. Monthly. $3.00 a year, 25c a copy. Articles on food manufacture, food legislation, and experiments in nutrition.

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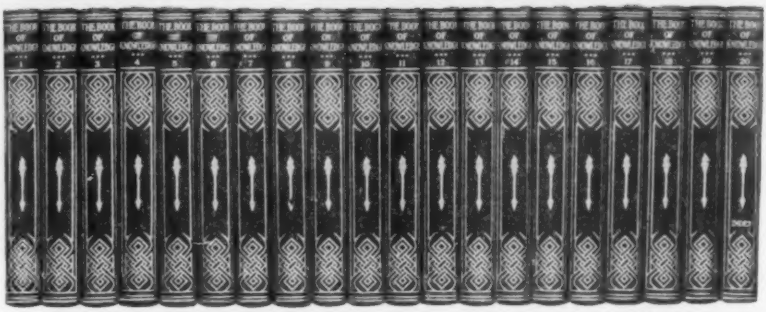

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The Geographical Review. Broadway at 156th Street, New York. Quarterly. $1.25 a copy, $5.00 a year. Devoted to scientific geography. Original maps and piectures. One department contains condensed items of topics of current interest.

The Guide to Nature. Sound Beach, Conn. Monthly. 15c a copy, $1.50 a year. Ill. Of interest to elementary pupils and teachers of nature study.

Hygeia. 535 North Dearborn St., Chicago. Monthly. 25c a copy, $3.00 a year. Popular articles on individual and community health. A valuable supplement to classroom work in hygiene.

Industrial and Engineering Chemistry. Box 505, Washington, D. C. Monthly. 75c a copy, $7.50 a year. A technical journal which contains much material which teachers can use.

Journal of Chemical Education. Kodak Park, Rochester, N. Y. Monthly. $2.00 a year. Promotes chemical education; primarily a journal for the chemistry teacher. Digests of activities of chemical associations.

Journal of the Franklin Institute. Philadelphia, Pa. Monthly. 50c a copy, $6.00 a year. Ill. A technical journal. Contains many articles of value to science teachers.

Journal of Home Economics. 617 Mills Bldg., 700 17th Street N. W., Washington, D. C. Monthly. 25c a copy, $2.50 a year. For teachers.

The Literary Digest. 354 Fourth Ave., New York. Weekly. 10c a copy, $4.00 a year. Has a department, "Science and Invention." Articles are mostly digests from other journals. They are popular in nature and suitable for high school pupils.

National Geographic Magazine. Washington, D. C. Monthly. 50c a copy, $3.50 a year. Best monthly journal for high-grade pictures. Articles are of interest to general readers, pupils and teachers, as well as to geographers.

The Nation's Health. 22 East Ontario Street, Chicago, Ill. Monthly. $3.00 a year, 25c a copy. An illustrated magazine devoted to community, industrial and institutional health problems. Very helpful to the science and hygiene teacher.

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